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HEARINGS

BEFORE THE

SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS HOUSE OF REPRESENTATIVES

EIGHTY-SIXTH CONGRESS

SECOND SESSION

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COMPARISON OF UNITED STATES AND U.S.S.R. SCIENCE EDUCATION

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DEPOSITED BY THE
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NATIONAL SCIENCE FOUNDATION

WEDNESDAY, MARCH 2, 1960.

WITNESSES

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PAUL B. SEARS, CHAIRMAN, CONSERVATION PROGRAM, YALE UNIVERSITY
JULIUS A. STRATTON, PRESIDENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY
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Mr. THOMAS. Gentlemen, will the committee please come to order?

We have with us this morning representatives of the National Science Board and the National Science Foundation. We are certainly delighted and honored to have so many distinguished gentle-

men with us. We have our very able and distinguished friend here, Dr. Gross. Welcome aboard, Doctor.

Dr. GROSS. Thank you.

Mr. THOMAS. We have with also Dr. Sears, chairman of the conservation program of Yale University. Doctor, we are delighted and honored to have you with us.

Dr. SEARS. Thank you, sir.

Mr. THOMAS. Then we have Dr. Stratton, president of the Massachusetts Institute of Technology. Where is Dr. Stratton?

Dr. STRATTON. Here, sir.

Mr. THOMAS. We are certainly delighted to have you, sir, and we hope that your time will permit you to come back to see us quite often.

Then we have Dr. Volwiler, chairman of the board of Abbott Laboratories. Where is he?

Dr. WATERMAN. His train has not gotten in as yet, Mr. Chairman. I expect him any minute.

Mr. THOMAS. Well, we appreciate his making the effort, and I know it is an effort.

Dr. Gross said he left home early this morning.

Then, gentlemen, we have with us from the National Science Foundation our able friend, Dr. Waterman, who is the Director; Dr. Bolt, Associate Director of Research; Dr. Harry C. Kelly, an oldtimer with us, who is the Associate Director of Educational and International Activities.

Where is Dr. Klopsteg?

Dr. WATERMAN. He will be in during the day.

Mr. THOMAS. He is certainly another remarkable individual; is he not?

Dr. WATERMAN. He certainly is.

Mr. THOMAS. He is an exceptional man with outstanding ability.

Then we have Dr. Dees, Assistant Director for Scientific Personnel and Education; Dr. Robertson, Assistant Director for Mathematical, Physical, and Engineering Sciences, and here is one of our big rocks of Gibraltar, Dr. Revelle, Chairman of the Divisional Committee for Mathematical, Physical, and Engineering Sciences; and Director of the Scripps Institution of Oceanography.

Welcome aboard, Doctor.

Dr. REVELLE. Thank you.

Mr. THOMAS. Here is one of my fellow Texans, Dr. Reid, also of the Scripps Institution of Oceanography. It is nice to have you with us, Doctor. We hope Dr. Revelle gets your business in shape where both of you can come more often.

Then we have Dr. Keller, who is the Mathematical, Physical and Engineering Sciences Program Director of the Astronomy program. He is running our laboratory out here.

Then we have Dr. John T. Wilson, Assistant Director for Biological and Medical Sciences; Dr. Adkinson, who is head of the Office of Science Information Service; Dr. Joyce, head of the Office of Special International Programs; Dr. Riecken, head of the Office of Social Sciences; Mr. Colman, executive assistant to the Director; Dr. Perlman, head of the Office of Special Studies. Dr. Perlman is an oldtimer with us now. Doctor, welcome aboard. We have not seen you in 2 or 3 months. You have been hiding from us.

Then we have Mr. Luton, Assistant Director for Administration; Mr. Sheppard, Deputy Assistant Director for Administration, and the very congenial budget officer, Mr. Schoen. Mr. Schoen, you really came up with a nice, fine budget. It is one of the best I have ever seen, but next year I hope you split it not into three parts, but two.

We want to have a lot of speeches this morning, and I hope that you have at least 8 or 10 speeches for us this morning.

Dr. Waterman, you take charge, and you run the show according to the way you want to. We are delighted to have you.

Dr. WATERMAN. Thank you, sir.

Mr. YATES. Doctor, do you want to make your statement first, or would you prefer that the members of the Board make theirs first?

Dr. WATERMAN. I thought I would make some general remarks, and then call on the members of the Board, and the statement can go into the record when we get directly to the budget details.

Mr. YATES. I think perhaps it might be well for you to make your statement at this time.

GENERAL STATEMENT OF DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. WATERMAN. Mr. Chairman, first I want to say that we are very sorry that Dr. Bronk was unable, as you know, to be here. I would like to report, however, that the collapse he had is not now regarded as serious and he will be around in a few days. It is just a matter of getting a little rest.

Mr. THOMAS. We are sorry to hear about his illness.

Dr. WATERMAN. In his absence, Dr. Gross, Vice Chairman of the Board, of course, will take his place.

First, Mr. Chairman, I would like to mention a few highlights with regard to our program, and to sum up the attitude we have in the Foundation which is strongly endorsed by the National Science Board and can be taken to be the opinion of thoughtful scientists and engineers throughout the country who are taking very seriously the role of the United States in science and technology. Of course, this country is not alone in that, because since the war the other countries of the world have realized that not only their defense but their economic strengths depend upon science and technology. They have made very rapid strides, particularly the very industrial nations, like not only Soviet Russia, but Germany, Japan, and China. They have been coming along fast. This is a real challenge, and we are concerned that this country maintain its leadership and do its duty by the free world by the quality of our effort. That is really where we can take a lead. Not only the National Science Foundation, but the Federal Government, is bending every effort to that end.

Two outstanding items in the public mind are, of course, defense, which is all important, and also the country's effort in space research, which is a critical one. But, quite apart from that, our feeling is that in order to do right by science and technology it is very necessary that we support competent basic research people so that the progress of science can advance, provide material for engineers in their developmental work and provide new ideas for development by industry and by Government. This is a must because only in this way will we know what is possible for technology to do. If we fail to do this, we will not know what the possibilities are. Out of those

we should be able to make a good selection of enterprises we have to go into in a big way. That we will have to watch, because these developments, in contrast with research, cost a lot of money and that is where we need to exercise great care in selection.

The other side of science and technology, of course, is the educational side where it is necessary to program ahead, to be sure that those who have aptitude for science and engineering know this, that they have opportunities to go ahead under good instruction and to go as far as they can in advanced studies.

The Foundation's program, as you know, is designed pretty largely to help along those lines and also to provide our scientists and engineers with what they need in the way of research facilities and equipment.

That is just a general summary of our program point of view.

The concern which is expressed by scientists and engineers is a genuine one, and can be summarized very briefly for you in three quotations which I would like to make. The first one comes from Admiral Burke, Chief of Naval Operations, who made the following observations:

> Our country has grown strong in an environment of personal liberty, human dignity, and sound moral and spiritual values. Today, however, in our preoccupation with fringe benefits, higher pay for less hours of work, two cars and a motorboat for every family, we run the grave risk of becoming complacent in our position of world leadership, and of becoming indifferent to the realities of the hard competition we face from the Soviets.

The second is from a statement of Mr. Allen Dulles in a hearing before a congressional committee as follows:

> The major thrust of Soviet economic development and its high technological skills and resources are directed toward specialized industrial, military, and national power goals. A major thrust of our economy is directed into the production of the consumer-type goods and services which add little to the sinews of our national strength. Hence, neither the size of our respective gross national products nor our respective industrial production is a true yardstick of our relative national power positions.
>
> The uses to which economic resources are directed largely determine the measure of national power.

The third is this——

Mr. YATES. That sounds like Galbreath instead of Dulles.

Dr. WATERMAN. The third is really an amazing statement. It dates back more than 50 years, and was made by Alfred North Whitehead, the well-known British mathematician and philosopher. This is taken from an address he gave to the British Association in 1916; it concerns education.

> When one considers in its length and in its breadth the importance of this question of the education of a nation's young, the broken lives, the defeated hopes, the national failures which result from the frivolous inertia with which it is treated, it is difficult to restrain within one's self a savage rage. In the conditions of modern life the rule is absolute—the race which does not value trained intelligence is doomed. Not all your heroism, not all your social charm, not all your wit, not all your victories on land or at sea, can move back the finger of fate. Today we maintain ourselves. Tomorrow science will have moved forward yet one more step, and there will be no appeal from the judgment which will then be pronounced on the uneducated.

That is a very strong statement, and yet it stands up over the years with increasing emphasis, and is especially pertinent now.

Mr. THOMAS. Doctor, one of the best things that this distinguished group can do this morning, and one of the best things it can accomplish during the day, we will say, is to put in the record and let us go into it in some detail some time before you leave here, an accurate evaluation and comparison between the Russian system of education and ours. Particularly with reference to the numbers of high school graduates that they are turning out compared to ours, and the number of college graduates with B.A., B.S., and up through the doctorates which they are turning out per year, and compare the quality of the work they are doing.

I am receiving hundreds of letters every month from people all over the country, and my own State, as well as other States. I am sure that the other members of the committee are likewise receiving such correspondence. A lot of them make the flat statement that we are years and years ahead of Russia in all fields of educatitonal activity, and that the effort which is proposed in one form, shape, or another by this Government and by this country generally is just so much wasted time and energy if it is directed toward staying ahead or being ahead of Russia. There has been someone who has been very effectively telling the American people that it is all a myth as to what Russia is doing in the educational field and that we are years and years and years ahead of them; that we have nothing to fear from Russia in the field of education, and so forth.

Now, this group assembled here has some very accurate information on that subject, and it is accurate because it is firsthand. Many of you have been to Russia and many of you have seen their system in operation and, if not, you have studied reports from Americans and others who have studied their system. So, before you leave here today, we want someone to address themselves to that subject.

Mr. YATES. Mr. Chairman, may I ask for some supplementary information?

Mr. THOMAS. Surely.

Mr. YATES. In his remarks Dr. Waterman pointed out that he thought with respect to the competition in which science finds itself among the nations of the world today we at least could excel in quality.

Dr. WATERMAN. Yes, sir.

Mr. YATES. I gather from this you have discarded the question of quantity? I am not sure whether this is true. What I would like to have from you is an appraisal of American science in relation to the other nations of the world, including the Soviet bloc, of course, in terms of whether our position is improving or whether it is retrogressing and what steps you think we should take in order to improve our position.

Dr. WATERMAN. All right.

Mr. RHODES. Mr. Chairman, may I also ask, if it is known with any degree of accuracy, that the same treatment be given to the Communist Chinese as far as their progress is concerned?

Mr. YATES. I assumed they were part of the Soviet bloc.

Mr. THOMAS. Let us make a clear record, first, with regard to Russia and then with regard to the Russian bloc, if that is available, as well as the Chinese. The main thing is to have a clear record on Russia first.

Mr. RHODES. Yes.

Dr. WATERMAN. Would you like to take that up now, Mr. Chairman?

Mr. THOMAS. Whenever it suits your pleasure.

Dr. WATERMAN. I want to be sure that the Board members get into the general discussion here. But first I should like to say something about some of the questions that have been asked.

Mr. THOMAS. Well, proceed as you think best to bring out the kinds of information that we need.

PROBLEM OF QUALITY IN DEVELOPMENT OF PROGRAMS

Dr. WATERMAN. To begin with, we have, of course, been aware of the threat that Russia might surpass us in science and technology. We have weighed the problem of quality versus quantity in the development of our programs for both education in the sciences and support of basic research. We must have quality all the way along the line—from the schools and colleges through the graduate schools. Otherwise, quantity—or numbers—has very little meaning.

In my opinion, the United States should not attempt to improve its educational system solely because of the fact that we see competition arising in the Sino-Soviet bloc. Our own growing national needs indicate that we should have been doing this all along, for reasons which are inherent in our own way of life. Nevertheless, in view of what is happening in Russia and the satellite countries and in Red China, it is apparent that we may be falling behind and that we must take firm steps to buttress our own scientific and technological educational system.

Although we have more colleges and universities, the Russians are placing relatively more emphasis than we are on scientific and technical education. Their scientific and technical labor force is growing at a greater rate than ours—for that matter faster than for the free world as a whole. Russia is producing engineers about three times as fast as we are, and at our present rates we will probably not be producing as many engineers even by 1970 as the Soviet Union is producing now.

The picture is not altogether dark, however. Our total number of scientists and engineers is still larger, by a small margin, than in the Soviet Union. In certain areas—particularly at the most advanced degree levels—our rate of production is still higher than theirs.

There is no reason for complacency, however. To maintain our scientific and technological supremacy we must intensify our efforts to improve the quality of our education in the sciences at all levels and to increase the numbers trained as we are able to.

The most heartening thing that I can report, Mr. Chairman, is the willingness of those in the scientific and educational communities with whom we work—students and teachers in the secondary schools, college and university teachers, research scientists, and scientific organizations—to work toward the same general goal of excellence. We need still to improve public understanding of the goals of science and of the need for strengthening our educational programs, but even now many communities are willing to cooperate as best they can. We are making a good start, and can see positive results. What is needed

is emphasis upon the importance of these steps and, next, how local communities can help.

Mr. THOMAS. Thank you, Dr. Waterman. Proceed with your regular program.

Dr. WATERMAN. You would like me to complete my statement?

Mr. THOMAS. Yes.

STATUS WITH RESPECT TO SCIENCE AND TECHNOLOGY

Dr. WATERMAN. The main thing I would like to add, Mr. Chairman, is a general summary of where we stand with respect to science and technology. This can profitably be looked at, I believe, by considering three categories: One is the progress of science itself. Now, this is a matter which has to be determined by the scientific community. They know best where to go and where to get significant results, and Federal agencies know what they need by way of science and technology. This is a subject which the Federal Government has addressed itself to directly, and almost the entire research and development program of the Government is of this character—getting on with the progress of science and technology directly.

The second category is the development of individual scientists and engineers. Much that the Federal Government has done here has been by fellowships such as our fellowship programs and that of NIH and also by way of assistance to individual scientists, especially graduate students employed in research grants and contracts where they can be supported and provide research training. Then, too, there are training grants, particularly by the National Institutes of Health, and, as you know, the Foundation supports institutes of many varieties for teacher training. All of these help develop the individual. We have made a good start in that.

The third category is to strengthen the development of our research and educational institutions. This is a field where we have done relatively little, and this is getting to be a serious need because by supporting research in the form of special projects, as we do, we earmark research efforts at universities, which then begin to lose their flexibility and the well-rounded growth of their departments. This increasing outside support of research projects puts them in a straitjacket with regard to the development of their own institutions.

PROBLEM OF ASSISTANCE TO UNIVERSITIES AND RESEARCH INSTITUTIONS

We find now that the universities and research institutions in general are embarrassed in two important ways: One is in the payment of maintenance and operation costs of work which the Government is supporting directly. The other is what can be done to assist the institutions to develop their own strength in their own way. Now, I mention this because the Foundation is taking steps which can assist in both these difficulties. The first is one we have already taken. We have looked the situation over carefully and have noted the increases in indirect costs faced by universities. Accordingly, we have increased our indirect cost payments to universities on research grants from 15 to 20 percent of the total direct cost.

Also, a plan originally recommended by our Government-University Relationship Committee, a very distinguished one, and endorsed

by the National Science Board, permits the university to state whether it would prefer to have indirect cost paid as a flat rate such as 20 percent, or whether they would prefer to have a negotiated rate such as is now done by AEC and the Department of Defense. This latter would be probably the fairest method to enable them to cover those costs completely. These two things we have in mind.

Mr. THOMAS. What is the limitation on costs with the NIH program? Is it 15 percent?

Dr. WATERMAN. Fifteen percent at the present time.

RELATIVE EXCELLENCE OF UNITED STATES AND U.S.S.R. EFFORTS IN SCIENCE

Dr. STRATTON. Mr. Chairman, I take it you wish this to be an informal conversation, in which all of us may join. You asked initially a question about the relative merits of the Russian and American systems of education and our relative positions in various fields of science. These are matters upon which the Science Foundation has as much or more information than any other group in the country, and I should like you to ask Dr. Waterman how he feels about the relative excellence of the Russian and American efforts in science. I ask how the quality of American science compares with that of the Russians because I suspect that in the matter of quantity, of magnitude—that is of our total effort, we are not competing successfully. Accordingly, it has seemed to me that our salvation will lie in our ability to do things better and faster. And what does the Foundation feel about our present position, Dr. Waterman?

Dr. WATERMAN. With respect to Russia?

Dr. STRATTON. I think that is the question you put, Mr. Chairman.

Dr. WATERMAN. We have had, of course, a great deal of information about this from travelers to Russia, and also from the studies which have been made, and all things considered, as Dr. Stratton says, since our population is not really so large as Russia's, and certainly——

Mr. THOMAS. It will not be long before it will be. The people over in the Department of Commerce are pretty good guessers and they say in about 22 or 25 years we will have 350 million people. We have 175 million now, and Russia has only 210 million. So, the gap is not too far apart now.

Dr. WATERMAN. This depends on their rate, too, of course. We feel that in this game—the science and technology game—it is quality that really counts, because this is where you have the skill which allows or determines whether you can take the leadership or not. This is what really counts. Our evidence at present is that in quality of research, judged by the findings we make and the papers we publish, we are really second to none, speaking generally, and the Russians are very close in many fields. To make a more detailed statement one would have to mention specific fields. The Russians are especially good in polar research. They have paid more attention to that than we have. They are very good in their systematic seismological and geological studies. They are good, but not superior, in astronomy and mathematics; in theoretical physics they are very good, and our opinion is that they are pretty much on a par with us, probably; in experimental physics we have a very definite edge. Their great weak-

ness, of course, is in the straight biological sciences where they have been out of date because of their philosophy with respect to the Lysenko movement. By and large, speaking generally, the concern is not the present quality but the future. Unless we can support our research people and their ideas more fully and unless we can make sure that those who have aptitude for science and engineering are actually trained and not missed—great numbers of them—we are not doing our best. And unless we do our best the consequences will be serious.

The opinions of our scientists who have gone to Russia are very much that while we can hold our own very well with them now, when they look at the very thoroughly trained young people in the field coming along who are bright and keen and who are given every opportunity, they are concerned over whether we are doing right by our own research people. So, it is the future that we are really thinking of.

Now with respect to what Russia is doing about the exchange of scientific information among their scientists, that will be discussed later, more specifically, but they have a center set up for that purpose.

Dr. REVELLE. Mr. Chairman, I might add a couple of footnotes about this particular subject. Right now one of the Russian oceanographic ships is operating off Cape Hatteras and to the north as far as New England, making studies of the Gulf Stream. It has been there for the past month or so. This is the *Michael Lomanosov*.

They also had people in New York at the time of the World Oceanographic Congress in September.

They have a ship which is something like four times as big as any of ours, with a scientific party of some 65 people. I looked it over in New York and it has the most modern equipment and a very systematic program. In fact, they attempt to coordinate all possible types of observations in the marine sciences—biological, physical, and chemical as well as geological—the results are equally comprehensive, and of lasting value in terms of the contribution to what one might call systematic surveys of the ocean.

One of the striking things about the ship, as about all Russian science, is that they are not, as we are, wasting half the brains of the human race by inhibiting women from going into scientific work. There are many women scientists on board, and some of them are in quite responsible positions.

Second, at the IGY meeting in Tokyo which I attended a few years ago, there was a group of 10 Chinese scientists. These were men of great sophistication and experience in science, totally familiar with the mathematical and theoretical foundations of geophysics. They could hold their own in discussion with any of the Americans there.

Third, in space research, we are familiar with the fact that the Russians have rocket engines with three or four times the thrust of any of ours. This is not due simply to a massive effort, but to a systematic development. The Russians started with small rockets and worked up stepwise, very thoroughly, to big ones. Apparently their ability to produce engines of such large thrust depends upon a very thorough knowledge of the performance of the rocket fuels, both the liquid and the solid. They evidently have much more control over their fuels than we have over ours, and can predict their performance better.

Mr. OSTERTAG. What do you mean by "control over the fuels"?

Dr. REVELLE. Knowing how the fuel is going to perform and what its variability is. They seem to know it better than our people do. This is based, obviously, on a broad program of experimentation.

Mr. THOMAS. May I ask you a question along this line? I have known the Chief of the German Naval Operations Division for 10 years. He is certainly a student.

Off the record.

(Discussion off the record.)

PROGRESS OF U.S.S.R. IN OCEANOGRAPHY

Mr. THOMAS. What is the quality of their work in your field, Dr. Revelle? What have they done?

Dr. REVELLE. There were over 60 Russian scientists at the International Oceanographic Congress in New York, a considerably smaller number than the number of Americans, naturally, because the meeting was held in our backyard. They presented about 150 scientific papers of varying quality. The best papers were in the field of turbulence—turbulent flow. Here they had conducted experiments which we have been talking about for the past several years, but they have done them and done them very well.

Typical of Russian oceanography is the systematic and long-term approach; that is, starting right from scratch to obtain precise and wide-range information.

Dr. WATERMAN. They have a large number of facilities also which go with this.

Dr. REVELLE. Of course, this involves many ships.

Dr. SEARS. The chairman is not interested in the amount of work they are doing, but the quality of it.

Dr. REVELLE. I think our impression would be something like this: That in the marine sciences the Russians are not now conducting a range of investigations as broad as ours, nor in many respects as imaginative programs as the ones being conducted by the British and ourselves. But they are building on a, perhaps, much more solid foundation both in terms of training and education of their people and the numbers of people who are going into this field in their systematic and well-planned approach.

Mr. THOMAS. Would you say that as of today they are ahead of us in the field of oceanography?

Dr. REVELLE. I do not think they are ahead of us at the present time. I think we have the same problem here that Dr. Waterman has already spoken about: that the thing to worry about is the trend and not the present status.

Mr. OSTERTAG. When you speak of oceanography and their studies and scientific application, you are embracing the Department of the Navy's effort, and all American efforts?

Dr. REVELLE. In this connection, sir, I am talking only about their scientific studies and not their developmental work.

Mr. OSTERTAG. The Department of the Navy is going into scientific studies; is it not?

Dr. REVELLE. I am talking about Russian scientific studies.

Mr. OSTERTAG. I am talking about our own Navy.

Dr. REVELLE. The Navy is supporting a great deal of scientific research in the marine sciences. I was not thinking of the actual development of antisubmarine warfare instruments which are, of course, in the long run based on these scientific studies. The science has to stay about 10 years ahead of the actual operations.

Mr. THOMAS. You are addressing yourself to pure research?

Dr. REVELLE. Yes, sir.

Mr. THOMAS. You may proceed, Dr. Waterman.

Dr. WATERMAN. On this general subject of oceanography I could add that I am sure the committee knows there has been an excellent report under the auspices of the National Academy of Sciences—National Research Council on what should be done in oceanography which has been taken very seriously. We have a part to play in carrying it out.

There is a special committee under the Federal Council of Science and Technology which is looking at that with great care so that it can be determined what each agency is going to do, and how this will measure up with the needs, and this is under due process.

Mr. THOMAS. I notice you transferred some of your money to that Council. How does that Council fit in with the National Academy of Sciences?

Dr. WATERMAN. We do not support the Federal Council, Mr. Chairman.

Mr. THOMAS. I thought you transferred some of your funds heretofore that you carried in your budget, but which are now carried in the budget of the Council.

Dr. WATERMAN. I do not think the Federal Council has any budget other than its administrative expenses. This is under the Executive Office of the President, and the agencies do work for it on special studies, but they do not transfer funds. They do not operate. They are just an advisory committee to the President.

I am reminded that we had provided funds for a study which was made by the Council. I stand corrected, Mr. Chairman.

Mr. THOMAS. You may proceed.

Dr. WATERMAN. That is all they do—make studies and recommendations and not operate.

Mr. YATES. Does the fact that the Russian oceanographic ship that is conducting these studies off the coast of Cape Hatteras and sweeping north on our northeastern coast have any military significance?

Dr. REVELLE. It does.

Mr. YATES. Is this the basis for their studies at this particular time? Do we do the same thing off the coast of Russia?

Dr. REVELLE. We do our best. However, we do not have the ships of the size or the capacity that they have.

Mr. YATES. Is this a real handicap? Is size a factor in the amount of research you can do?

Dr. REVELLE. In this particular case it is a handicap. When I say it has military significance, I mean this not that they are spying, but they are obviously thinking they may want to operate in these waters or to know about them.

Mr. YATES. What is the nature of the survey which they do? Is it a survey of the contour of the ocean floor?

Dr. REVELLE. They are primarily studying the Gulf Stream.

Mr. YATES. Do they also study the contour of the ocean floor?

Dr. REVELLE. I do not know whether they are doing this or not. Probably their ship is not getting enough information to be very useful as far as the utilization of the sea floor is concerned.

Mr. JONAS. Have you been invited aboard?

Dr. REVELLE. No American oceanographer has ever been aboard a Russian ship.

Mr. YATES. That is, except in the harbor?

Dr. REVELLE. Yes, sir; many times in the harbor, but not at sea.

Mr. YATES. You said the Russians were building on a more solid foundation for the study of the science of oceanography in the future, and you felt that, perhaps, the Americans and the British had a more imaginative program. Do you know whether they are expending as great an effort as we are, or a greater effort than we are, in this science?

Dr. REVELLE. I believe they are expending a bigger effort.

Mr. YATES. Do you have anything on which to base that?

Dr. REVELLE. It is based on the number of Russian marine scientists.

Mr. YATES. Have you been able to gather from the conversations you had with the Russian marine scientists that this was just one small branch of their total effort?

Dr. REVELLE. You mean the operations of this particular ship?

Mr. YATES. The operation of the ship and the fact that they had 65 members at this convention.

Dr. REVELLE. We know how many ships they have—how many big and little ships they have.

Mr. YATES. Do we know this as a matter of fact?

Dr. REVELLE. Yes; they told us. There was nothing secret about it.

Mr. YATES. In retrospect, my question seems somewhat naive in asking you whether or not this sweeping of the Russians along the coast had military significance.

Dr. REVELLE. It has in the sense that the more you know about the ocean, the better you can operate a submarine.

Mr. YATES. I remember in response to certain questions relating to space, the President of the United States indicated our scientific experiments had no military significance; apparently he sees a distinction between the two.

I wonder whether or not this is true?

Dr. REVELLE. I will not argue about space, Mr. Yates, but I will argue about the ocean.

Mr. YATES. Doctor, do your scientific studies have military significance?

Dr. REVELLE. As far as the marine sciences are concerned, very definitely.

Mr. YATES. Do you have any opinion about space?

Dr. REVELLE. No, sir.

THE EDUCATION SYSTEMS IN THE UNITED STATES AND THE U.S.S.R.

Mr. THOMAS. Let us go back to the beginning. Let us go back to the high schools and get the numbers and some opinion on the quality; then go to the universities and to the numbers of graduates with B.A., B.S., and above, and compare them with ours. You have to start them out in high school and you have to go to college before you get

these outstanding scientists. Let us start at the beginning and get some accurate comparative ideas about it.

Dr. WATERMAN. Yes, sir; we have been studying these problems for a number of years, and my staff will be able to provide some up-to-date and fairly complete material. Of course, the fact is that Russians who go through what corresponds to our high schools all study science, and they study a lot of it. They take 10 years of mathematics for college, if I remember correctly; also they take 5 years of physics. In the first place, they have a centrally prescribed curriculum over there, as compared with our State and locally administered system.

Mr. THOMAS. I believe the period of time for mathematics is 9 years in the cities, and 7 years in the rural districts.

Dr. WATERMAN. Yes, Mr. Thomas.

Mr. THOMAS. And my information is that they were going to make it 9 and 9 last December. Whether they did or not, I do not know.

Dr. SEARS. Mr. Chairman, it may be of some interest to note that certain aspects of the Russian situation have very old roots. So far as education is concerned, it has been a practice since the days of Peter the Great for the Imperial Court or the local nobility to select young men of talent in the arts or sciences, and see that they get the very best education possible. This helps explain the many brilliant achievements of Russians in the days before the present regime. Where the present regime is hitting the jackpot is in making education generally available and thus widening the base of selection for scientific talent. It also has the power to route students who lack academic talent into useful work so that they do not clutter up the serious business of education.

Mr. RHODES. Actually, Dr. Waterman, have not the Russians lowered their sights a bit, as far as mass education is concerned, in the last few months?

Dr. WATERMAN. There have been some reports of that, and they have changed their system of decentralization with research institutes separate from the universities. They have moved back somewhat to put them in universities as we have. Apparently the research institute plan is not working so well. There is too great a specialization.

Mr. RHODES. I was thinking more of the possibility that they might have brought about a manpower shortage in industry or on the farm.

Dr. WATERMAN. As I understand it, low birth rates and the loss of men through the war have made it necessary to get youth into the labor force as quickly as possible. This has necessitated postponing or denying higher education to a great many of them.

Mr. RHODES. And, therefore, they had to lower their sights a bit.

Dr. WATERMAN. What is important to realize, I believe, is that the Russians who go to high school all study mathematics and science, not as specialists, but in a general way; whereas only a fraction of ours do.

Mr. YATES. How many go to high school?

Mr. THOMAS. Does anyone have some figures on this subject?

Dr. KELLY. Our staff has been collecting material of this kind for some time. We now have information about many phases of Russian education and can compare it fairly well with information about the United States.

The U.S.S.R. has been releasing a great deal of information recently on its scientific and technical work force and its educational system. Official information released by the Soviet Government has been sup-

plemented by the observations of visitors on exchange missions to the U.S.S.R. Then, too, there are materials published in other countries which are of some interest. Many of these sources have been used in the material we shall present. I can give you now some very brief summaries of some of the subjects you have requested.

Mr. THOMAS. Go ahead, Dr. Kelly.

Dr. KELLY. It might be well to begin with some general comments on overall comparisons. Education in the Soviet Union is completely designed for the purposes of the State. For world domination, their Government knows that they need people trained in science, technology, economics, geopolitics, et cetera, and the function of education is to produce the needed servants. The Soviets, in planning the future of their state determine the needs for people in different professions and thereby determine the number of students in each area. In the free world, education is directed toward the development of the individual. The young people in the Soviet Union know that a good way out of their low economic and social environment is through education.

The material rewards of training are real—better food and lodging, for example. Because we already have the physical amenities the Soviet people are still seeking, the motivations of our young people must not only include material rewards but also the more intangible—love of liberty and love of learning.

Now about numbers. Both countries try to educate their youth through the secondary school level. As you mentioned, Mr. Thomas, there is a reform underway, and the 7- and 10-year schools eventually may be replaced by the new 8-year and 11-year schools.

Despite the amazing progress of the U.S.S.R. in developing its educational system, we are still ahead of the Russians in the educational level of the population as a whole. As I recall, less than 2 percent of their citizens have completed higher education, compared with about 5 percent in this country.

COMPARISON OF SCHOOL AND COLLEGE ENROLLMENT

Mr. THOMAS. How do the numbers in school and college compare, Dr. Kelly?

Dr. KELLY. Altogether in our school and college enrollments we have about 10 million more in school than the Russians have. With respect to secondary school, we have about 80 to 85 percent of our youth of high school age in school while the Russians have about one-half of this age group in school. We have 3½ million students in our colleges and universities, and the Russians have just over 2 million. Furthermore, it should be kept in mind that large numbers of the specialized secondary and higher education students in the U.S.S.R. are enrolled in correspondence and extension courses.

Two other kinds of numbers may be of interest in this connection. One of these is the number of schools and colleges; the other is the number of teachers. We have about 145,000 elementary and secondary schools; in the U.S.S.R. there are a great many more—nearly 220,000 at the precollegiate level. Since we have several million more students at these levels, the schools in the U.S.S.R. must be smaller, on the average. Each country has about the same number of secondary schools—roughly 30,000. We have many more colleges and universi-

ties than the Russians—about 2,000 for the United States compared with 750 for the U.S.S.R.

Although we presently surpass the Soviets in total numbers going to school, we must remember that they are making great efforts to catch up. In some of their Republics, for example, they claim a decline in illiteracy rate from 85 percent to 15 percent in 40 years.

Mr. THOMAS. Dr. Kelly, can you be a little more specific on the question of how many go to high school, finish high school, and go to college for the two countries?

Dr. KELLY. I can give a rough indication of it. This is a very rough comparison, since our information is not precise. However, if we start with a given number of students—say 100—entering the elementary schools of the two countries, the United States will educate twice as many through the secondary level as the U.S.S.R.—about 60 of our students will finish secondary school compared with about 30 in Russia. At this point, there is a big difference also. About 30 of the 100 students in the United States will enter college, but only 10 will go on in Russia. About 15 of our students will graduate from college, compared with 7 in the U.S.S.R. Most important of all, in this connection, however, is that only 3 of our original 100 students will have trained as scientists or engineers—compared with 4 in the comparable group in the Soviet Union.

COMPARISON OF SCIENTIFIC STUDIES

Mr. THOMAS. One other thing in this connection, Dr. Kelly. A little while ago we mentioned the fact that children in Russian schools study more science than they do in the United States. Do you have some more specific information on this question?

Dr. KELLY. Yes, sir. I can give you some general information now.

Mr. THOMAS. Go ahead, Dr. Kelly.

Dr. KELLY. It is true that Russian students study more science in the elementary and secondary schools. For example, in Russia, science is a separate subject beginning in grade 4, compared with about grade 7 in U.S. junior high schools. Of course, there are exceptions here. In Russia, the fundamentals of physics are taught from grades 6 through 10. Instruction in chemistry starts in grade 7 and biology is begun in grades 5 and 6. In the United States general science is widely taught in grades 8 and 9, and typically only a single year of any science—biology, chemistry, or physics—will be offered in the secondary school. There are also some exceptions here, and most schools are beginning to expand their science offerings.

In both countries arithmetic is taught through the elementary level, but in the U.S.S.R. algebra and geometry are taught in grades 6 through 10 and trigonometry in grades 9 and 10. In the United States mathematics instruction usually does not extend at all beyond intermediate algebra, solid geometry, and trigonometry—and then not for all students but mostly for those who are planning to go to college. Many other secondary school students study business and commercial arithmetic instead of formal mathematics. About one-quarter of our high school graduates will have studied physics and less than 10 percent will have had solid geometry and trigonometry.

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There is a great deal of interest in the problem of the amount and kinds of science and mathematics that our schools should offer and significant changes—pointed in the direction of improving and expanding science offerings—are on the way.

Mr. THOMAS. Thank you, Dr. Kelly. This helps to clarify the picture, but it doesn't look too encouraging, does it?

Dr. WATERMAN. I might sum it up this way, so far. The Russians are making a tremendous effort to improve their educational system, especially in sciences and technology. And apparently they are having a great deal of success. They are working more seriously than we are to improve the education of their youth. Their motivations are different in many respects; their philosophy is different; and in many ways their needs are different. But we should not discount the progress that they are making. The big difference is that they can plan and direct their whole effort from a central authority. Our effort is based on freedom from central planning and depends on the understanding and cooperation of everyone concerned with the process. We believe that our way is best for the long run—but it means that individual persons and groups involved in policy and administration must take greater responsibility.

Mr. THOMAS. That is a good statement of our two positions, Dr. Waterman. We need all the information on this topic that we can get. Will you have some material to submit for the record on the comparison of the two educational systems, and the amount of science that is studied?

Dr. KELLY. Yes, sir. We are working on material of this kind now.

(The information requested follows:)

A SUMMARY VIEW OF THE EDUCATIONAL SYSTEMS

While there are several points of similarity in the educational systems of the United States and the U.S.S.R., the casual observer of the educational scene is more likely to be impressed by important differences. These have developed from the different political, social, and economic institutions of the two countries. Primarily, they emerge from the differing philosophies of the relationship between the State and the individual citizen. In the United States, all levels of government are considered to exist to serve the individual citizen. The Soviet State holds that the individual exists to promote the collective good as made manifest through the Government. While this brief comparison oversimplifies the basic differences, it is from these opposed concepts that many educational differences arise.

The U.S. educational system is diversified, and yet it generally has a standard pattern of 12 years of elementary and secondary school. There is general acceptance of the comprehensive high school concept, although vocational secondary schools are numerous in the larger cities.

The U.S.S.R. educational system is still in a developing stage. An educational reform now underway will result in substantial change in the secondary schools and higher education levels. Curriculum and textbooks are standardized by central authority. The general education 7- and 10-year schools will eventually be succeeded by the 8- and 11-year schools. Great emphasis is placed upon specialized vocational training at the secondary school level. Correspondence and extension courses enroll a large proportion of the specialized secondary and higher education students. The accompanying chart shows some of the more obvious differences in the two school systems.

The student spends about the same amount of time in elementary and secondary school in both countries. However, in the U.S.S.R. he starts in elementary school at age 7 and completes secondary school after 10 years of 6 days a week attendance. The typical pattern in the United States is entry into elementary school at age 6, and 12 years until completion of high school with 5 days a week attendance. Length of the school year is approximately the same.

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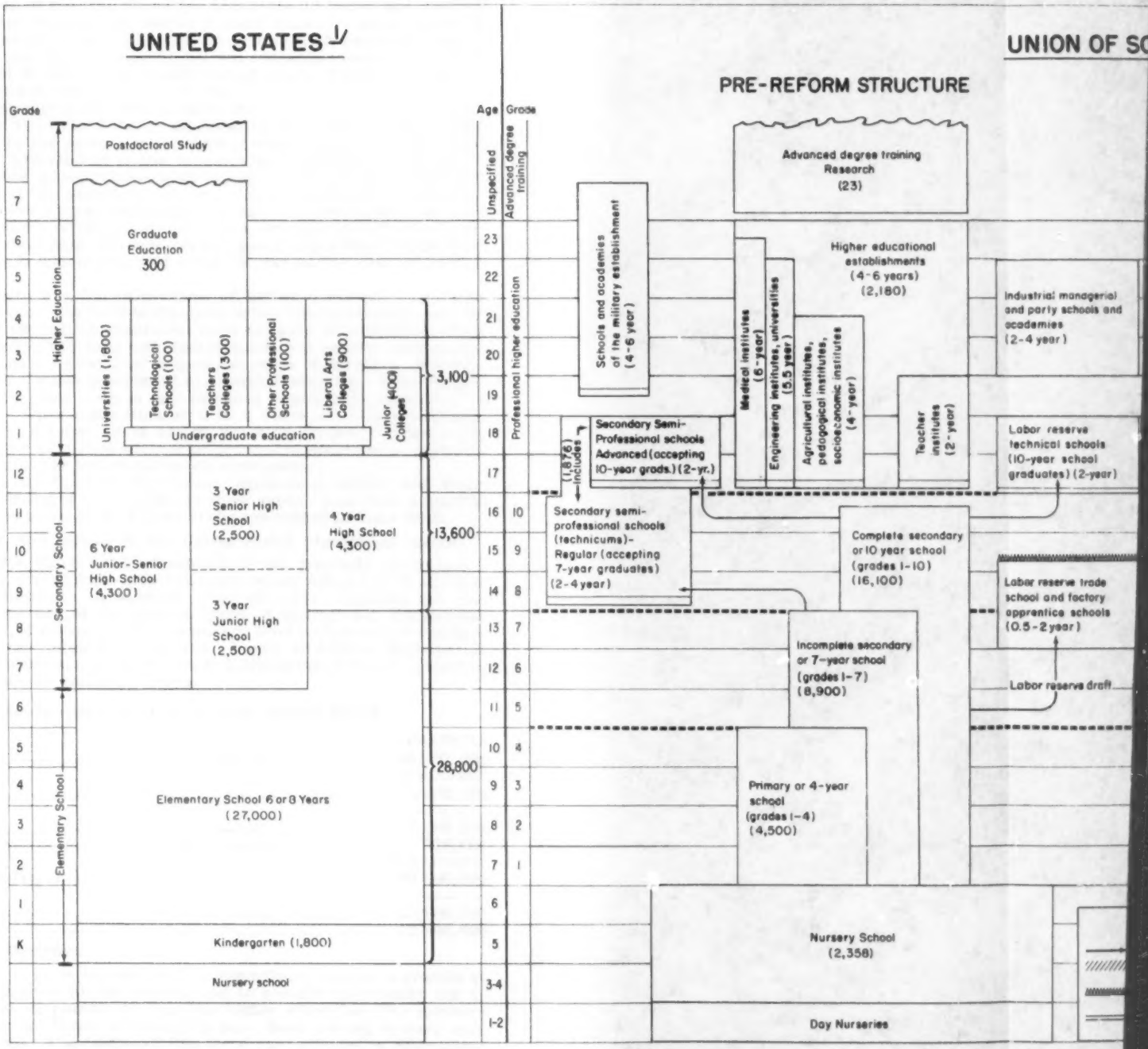
THE U.S. AND U.S.S.R. EDUCATIONAL


UNITED STATES 1/
Grade
Age
Postdoctoral Study
Graduate Education 300
Higher Education
Universities (1,800)
Technological Schools (100)
Teachers Colleges (300)
Other Professional Schools (100)
Liberal Arts Colleges (900)
Junior (400) Colleges
3,100
Undergraduate education
Secondary School
6 Year Junior-Senior High School (4,300)
3 Year Senior High School (2,500)
4 Year High School (4,300)
13,600
3 Year Junior High School (2,500)
Elementary School
Elementary School 6 or 8 Years (27,000)
28,800
Kindergarten (1,800)
Nursery school
Unspecified
Advanced degree training
Professional higher education
PRE-REFORM STRUCTURE
Advanced degree training Research (23)
Schools and academies of the military establishment (4-6 year)
Higher educational establishments (4-6 years) (2,180)
Medical institutes (6-year)
Engineering institutes, universities (5.5 year)
Agricultural institutes, pedagogical institutes, socioeconomic institutes (4-year)
Teacher institutes (2-year)
Industrial managerial and party schools and academies (2-4 year)
Secondary Semi-Professional schools Advanced (accepting 10-year grads.) (2-yr.)
(1,876) included
Secondary semi-professional schools (technicums)-Regular (accepting 7-year graduates) (2-4 year)
Labor reserve technical schools (10-year school graduates) (2-year)
Complete secondary or 10 year school (grades 1-10) (16,100)
Labor reserve trade school and factory apprentice schools (0.5-2 year)
Incomplete secondary or 7-year school (grades 1-7) (8,900)
Labor reserve draft
Primary or 4-year school (grades 1-4) (4,500)
Nursery School (2,358)
Day Nurseries
1/ Enrollment data where available are shown in the appropriate school system; estimated in thousands for year 1959-60
2/ Enrollment data where available are shown in the appropriate school system; estimated in thousand

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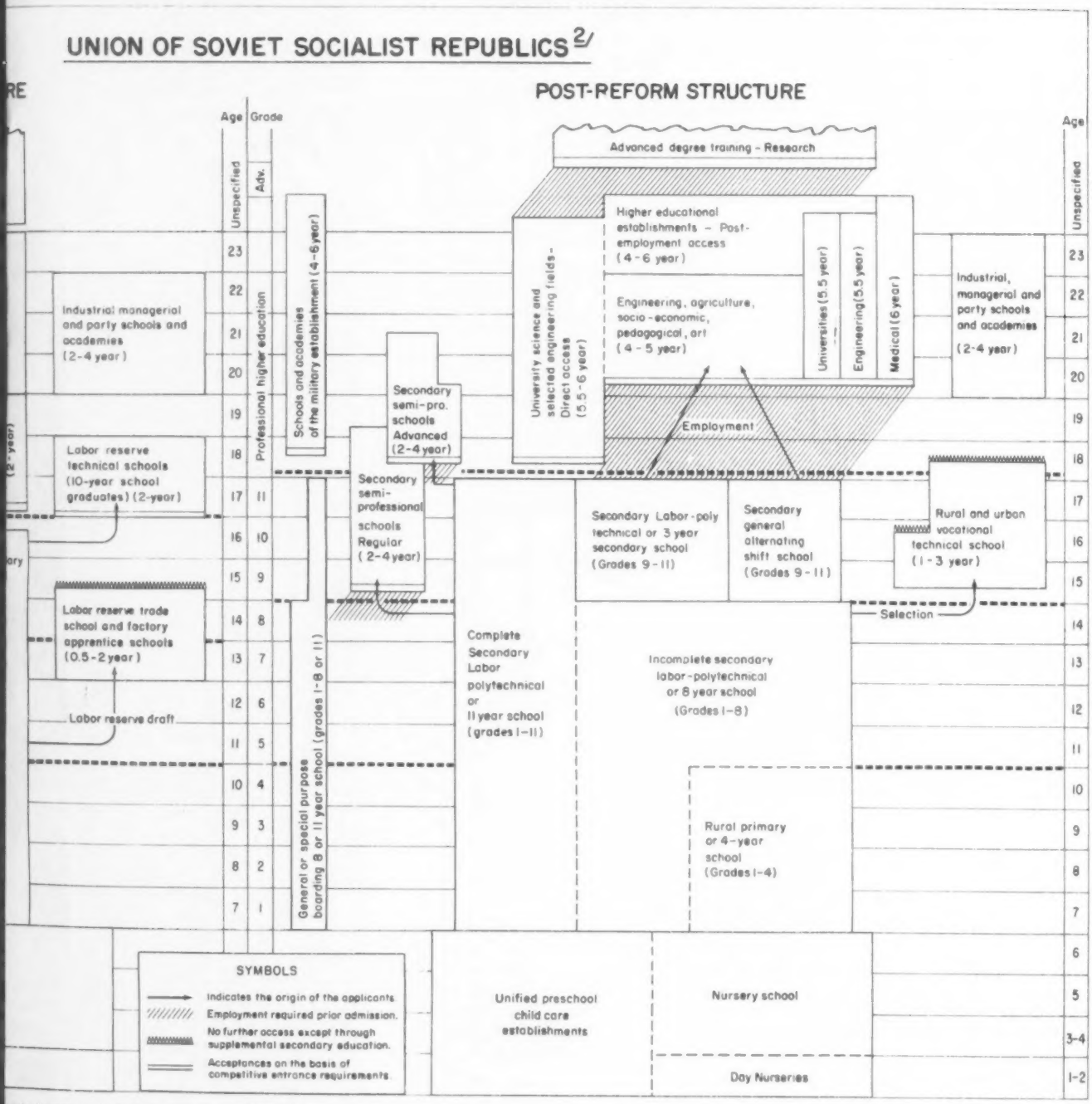
CATIONAL SYSTEMS - A COMPARISON

UNION OF SOVIET SOCIALIST REPUBLICS [2/]


POST-REFORM STRUCTURE
Age
Grade
Unspecified
Adv.
Advanced degree training - Research
Higher educational establishments - Post-employment access (4-6 year)
Engineering, agriculture, socio-economic, pedagogical, art (4-5 year)
University science and selected engineering fields - Direct access (5.5-6 year)
Universities (5.5 year)
Engineering (5.5 year)
Medical (6 year)
Industrial, managerial and party schools and academies (2-4 year)
Industrial managerial and party schools and academies (2-4 year)
Schools and academies of the military establishment (4-6 year)
Professional higher education
Secondary semi-pro. schools Advanced (2-4 year)
Secondary semi-professional schools Regular (2-4 year)
Employment
Labor reserve technical schools (10-year school graduates) (2-year)
Labor reserve trade school and factory apprentice schools (0.5-2 year)
Labor reserve draft
Secondary Labor-poly technical or 3 year secondary school (Grades 9-11)
Secondary general alternating shift school (Grades 9-11)
Rural and urban vocational technical school (1-3 year)
Selection
Complete Secondary Labor polytechnical or 11 year school (grades 1-11)
Incomplete secondary labor-polytechnical or 8 year school (Grades 1-8)
General or special purpose boarding 8 or 11 year school (grades 1-8 or 11)
Rural primary or 4-year school (Grades 1-4)
SYMBOLS
Indicates the origin of the applicants
Employment required prior admission.
No further access except through supplemental secondary education.
Acceptances on the basis of competitive entrance requirements.
Unified preschool child care establishments
Nursery school
Day Nurseries

e school system; estimated in thousands for year 1958-'59. Information on USSR supplied by Mr. Nicholas De Witt from forthcoming revision (1960) of "Soviet Professional Manpower."

Both countries strive to educate their populations through the secondary school levels. In the U.S.S.R., an indicated 97 percent of the population 12–14 years of age are enrolled in school, but only about one half of the 15–17 years of age group, if we include correspondence and extension courses. In the United States, about 82 percent of the high school age group (14–17 years) are enrolled in school. The relative youth of the Soviet Union's mass education efforts is indicated by the estimated 1.8 percent of its population with completed higher education in contrast with an estimated 4.9 percent college graduates in the U.S. population. A total of 46 million are enrolled at all levels of formal education in the United States, and 36 million in the U.S.S.R.

At the higher educational level, differences in the two countries become even more pronounced. In the United States, students have a choice of some 2,000 institutions, both public and private, which offer a wide variety of courses and levels of instruction. The student is free to select the institutions at which he will apply for admission in accordance with his own interests, his assessment of his capabilities, and his vocational choice. After completion of training, he is free to follow his own vocational goals. He and his family have typically borne most of the expenses of attendance at college, though the costs of attendance are in a sense subsidized through State support (in publicly supported institutions) or through endowment and other income in the case of private institutions.

In the U.S.S.R., there are 766 institutions of higher education (all State supported). These institutions include the universities (40 in number) and the 726 polytechnical and specialized institutes; each category of institution offers a relatively standardized curriculum and enrolls students in specific subjects and to the extent determined to be required to meet the needs of the state. The student may apply only to a single department at a single institution. Increasingly, sudents may apply only after more or less extended employment experience in the civilian economy. Upon completion of 2 to 6 years of training, he will normally be assigned to his first job in accordance with the needs of the state. Higher education is a state function without tuition cost to the student; typically, students receive stipends sufficient to defray all their costs.

Higher education in the U.S.S.R. emphasizes engineering, science, and medicine, and most of the diplomas are granted in these fields. Less than a quarter of the baccalaureates awarded in the United States are earned in these fields.

Enrollments, teachers, and schools in the United States educational system

In the United States, three levels of education are generally recognized—elementary, secondary, and higher—although many would add a fourth division in the latter level—graduate. Altogether, some 46 million students are currently enrolled in some one of the various types of educational institutions. The largest number is, of course, at the elementary level with nearly 30 million enrolled as shown in the following tabulation. Nearly 13 million students are enrolled in secondary schools, and 3.4 million in institutions of higher education (316,000 of the latter are in graduate study).

Enrollments by education level, 1959–60—United States

Level	*Enrollment*
Total	46,102,000
Higher education	3,402,000
Undergraduate	3,086,000
Graduate	316,000
Elementary and secondary	42,700,000
Elementary	29,900,000
Secondary	12,800,000

Source: U.S. Office of Education.

Generally speaking, it is an aim of the U.S. educational system to provide at least a secondary education for all persons and to provide opportunity for as many qualified persons as possible to complete higher education. The numbers of persons enrolled at all levels of education have been moving upward over the past several decades. The results of this trend are indicated in educational attainment data for the U.S. population. In March 1959, 8.3 million persons had

completed 4 or more years of college and another 10 million had completed 1 to 3 years of college. In addition, over 32 million persons have completed high school and another 27 million have completed 1 to 3 years of high school.

Since elementary and secondary curriculums are developed by the State and local educational authorities, the extent of science and mathematics instruction varies. Two generalizations may be made as to the extent of science and mathematics enrollments: (1) More than two-thirds of all high school graduates have had at least one science and one mathematics course; (2) since the advanced courses tend to be more sequential in nature, probably no more than a quarter or so of all students have 3 or 4 years of science and 3 or 4 years of mathematics. Three or four years of both science and mathemtics at the secondary school level are usually considered desirable if a student plans to enter college and major in a science or engineering field. Considerably less than a quarter of all high school graduates have the option therefore, at the time of graduation from high school, of considering a professional career in science as a realistic possibility.

At the college and university level, students enroll in science and engineering courses to satisfy a wide variety of needs. These include the vocationally oriented training of the engineering student, basic science courses for premedical students, specialized courses for the prospective graduate student, and the general cultural interest of the humanities student. Engineering enrollments are probably a fair measure of the number of students currently taking courses in these subjects. No comparable figures exist for the numbers of students enrolled in science courses, which can only be partially accounted for by the number of bachelor degrees awarded in science subjects. In the fall of 1959, engineering enrollments at the undergraduate level totaled 243,000, or 8 percent of all enrollments. Baccalaureate degrees in mathematics and science totaled about 42,000, or 11 percent of all such degrees in 1958.

Another way of describing the U.S. educational system is in terms of the number of schools. At the elementary and secondary levels nearly all schools are publicly controlled, mainly by local governmental jurisdictions. At the higher educational level, there is a greater proportion of privately controlled institutions; the private colleges and universities enroll somewhat less than half of all college students. At this level, the publicly controlled institutions are under the jurisdiction of States, counties, or cities; very few schools are federally controlled.[1] The following tabulation gives the number of educational institutions at the various levels in the United States. However, the number of schools at the elementary and secondary level is perhaps overestimated in view of the continuing trend toward consolidation.

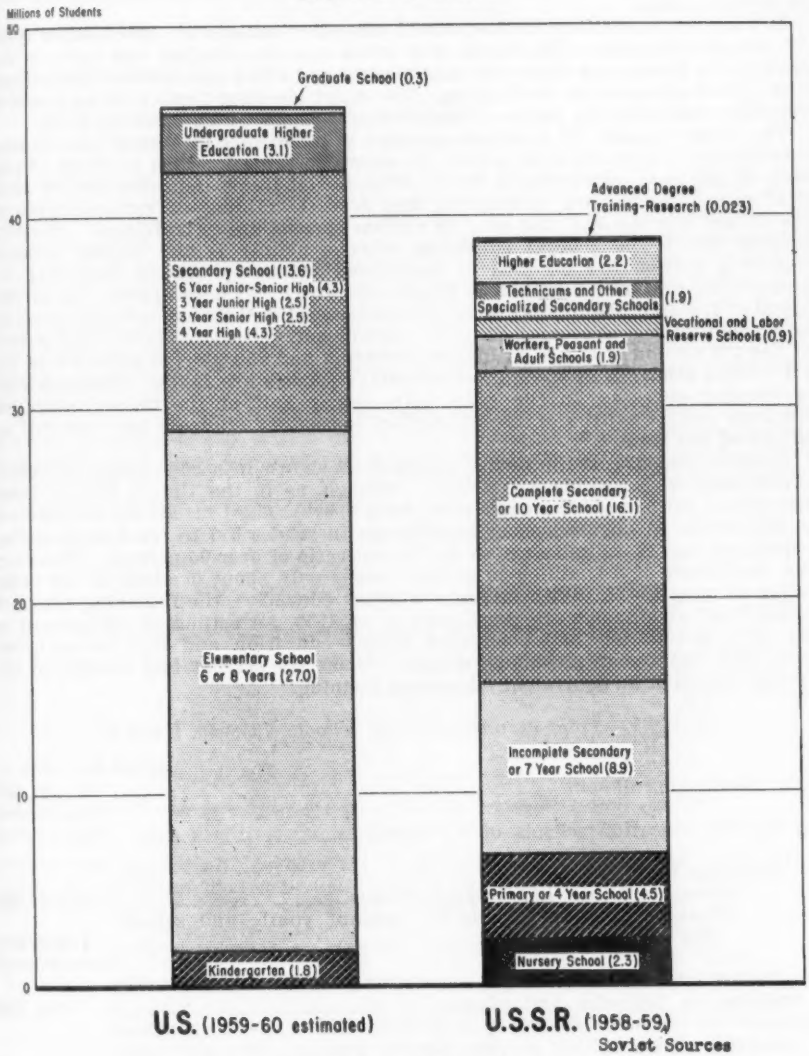
Number of schools, 1959–60—United States

Level	*Number of schools*
Total	148,000
Higher education	2,000
Elementary and secondary	146,000
Elementary	116,000
Secondary	30,000

Nearly 2 million persons are engaged in teaching in the Nation's schools as shown in the following tabulation. At the elementary and secondary level, the teachers are primarily full-time employed professionals. At the higher educational level the figure of 244,000 full-time professional teachers does not include several thousands of additional persons who assist in the instruction process in our colleges and universities on a part-time basis.

[1] Exceptions include the military service academies and the limited control exercised over Howard University and Gallaudet College.

CURRENT ENROLLMENTS IN FORMAL EDUCATIONAL SYSTEMS
U.S. and U.S.S.R.



U.S. Office of Education

Number of teachers in the United States

Level	*Number of teachers*
Total	1,810,000
Higher education	244,000
Elementary and secondary	1,566,000
Elementary	980,000
Secondary	586,000

Enrollments, teachers, and schools in the U.S.S.R.

In the Soviet Union, there are at least two different educational systems which compare with the U.S. elementary and secondary levels—the 7- and 10-year schools of general education. However, at the outset, it should be noted that

the U.S.S.R. is in the midst of an educational reform which in general extends the length and amount of education at these beginning levels. For the most part, the following discussion is confined to present or prereform practices as reported in Soviet sources.

Beyond or in addition to the general education schools are three other types of formal education: Vocational and labor reserve schools, and schools for training in plants and factories; tekhnikums and other specialized institutions; and higher educational institutions. The chart showing these various levels of schooling indicates the paths of progression through which students pass.

The total number of students enrolled at all levels in formal educational institutions is more than 36 million as shown in table 1. This is about 18 percent of the total population in 1959. (The Soviet Union indicates that in addition many persons are undergoing less formal training in various types of specialized courses and that over 50 million persons are in training.) About 32 million are in the general education schools, mainly 7- and 10-year schools. Nearly 2 million are enrolled in specialized secondary schools including the technicians, and over 2 million in higher education. At both of these latter two levels of training, the number of students who work full time or who are enrolled in correspondence or evening courses is significant. Nearly 850,000 (46 percent) of the 2.2 million students in higher education and 750,000 (40 percent) of the 1.9 million students in specialized secondary schools are taking correspondence or evening courses. In the same vein, nearly half of the higher education students and two-fifths of the specialized secondary students are reported as employed full time.

Another measure of the Soviet emphasis is shown in a comparison of school enrollments with specific age groups. Though, as in the United States, these age groups do not always correspond with specific class levels, the comparison is still valid. A comparison of enrollments in grades 5–7 to the corresponding population age 12–14 indicates an enrollment ratio of over 95 percent. However, the enrollment of 3.4 million in grades 8–10 is only about one-half of the population of ages 15–17. With respect to higher education, the following ratios of educational attainment are pertinent; as of 1959, an estimated 1.8 percent of the total population had completed higher education and 28.1 percent had completed the 7-year secondary school. About 6.3 percent had completed the 10-year school or an equivalent tekhnikum training.

TABLE 1.—*Total enrollment in all schools, 1958–59, U.S.S.R.*

	School year 1958–59
Total enrollment	36,442,000
In general education schools of all types	31,483,000
Includes those in—	
Primary, 7-year, and 10-year schools	29,567,000
Workers' schools, schools for peasant youth, and schools for adults	1,916,000
Vocational schools, labor reserve schools, and schools which provide training in factories and plants	904,000
Tekhnikums and other secondary specialized educational institutions (includes those taking correspondence courses[1] and extension courses)	1,876,000
Higher educational institutions (includes those taking correspondence and extension courses[1])	2,179,000

[1] The majority of those taking correspondence and extension courses are correspondence course students.

Another measure of the Soviet education system is the number of schools and students enrolled at the various levels. The table below gives the numbers of general education schools as of 1958–59. By far the largest number serves the primary grades and a sizable number are for the 7-year and 10-year enrollments.

Number of general education schools, 1958–59, U.S.S.R.

Type of school	*Number of schools*
Total	215,000
Primary (grades 1–4)	112,400
7 year (grades 1–7)	55,700
10 year (grades 1–10)	30,700
Other [1]	900
Schools for workers, peasant youth, and adults	15,300

[1] Schools for retarded and physically handicapped children.

The large number of schools when compared with enrollments indicates that many must be small and most of these are probably in rural areas. In fact, other data indicate that more than half of all students in the general education schools are in rural areas. As of 1959 there were 3,346 tekhnikums and other specialized secondary institutions. This is a slight drop from the previous year which may indicate a trend toward consolidation of smaller schools. In the same year, the Soviet Union had 766 higher education institutions which range from 6-year medical institutes to 2-year teacher-training institutes. This total included correspondence course institutions—which (as mentioned above) enrolled nearly half of all higher education students—as well as the 40 major universities of the U.S.S.R.

Altogether there are 1.9 million teachers employed in the general education schools, including nearly 200,000 part-time teachers. The level of qualification and training of these teachers varies considerably as shown by the following tabulation of training received by the more than 1.7 million full-time teachers in the primary and secondary system.

Type of training received	Teachers	
	Number	Percent
Total	1,758,000	100.0
Higher education	508,062	28.9
Teacher institute	406,098	23.1
Secondary	815,712	46.4
Those with pedagogical training	726,054	41.3
Those without pedagogical training	89,658	5.1
Less than secondary	28,128	1.6

Seventy percent of all teachers in the general education schools are female; nearly 90 percent of the teachers in the primary grades are women.

An illustration of the types of teachers engaged and training provided in Soviet secondary schools is shown by the following distribution of 900,000 teachers in the general education schools grades 5–10 according to subject matter of teaching:

Subject matter of U.S.S.R. teachers:	*Percent distribution*
All subjects	100.0
Language and literature:	
Russian	21.8
Native (non-Russian)	9.1
English	2.9
German	5.4
French	.8
History	12.6
Geography	6.3
Geography and natural science combined	3.7
Natural science	37.4
General [1]	6.7
Chemistry	4.1
Physics	5.1
Mathematics	13.7
Physics and mathematics	7.8

[1] Includes nature studies, botany, zoology, biology, and human anatomy.

Science and Mathematics Curriculums in Elementary and Secondary Schools

There is no doubt that the U.S.S.R. puts much more emphasis on science and mathematics instruction at the elementary and secondary school levels than does the United States. In the Soviet Union, science as a separate subject of instruction appears at the grade 4 level, and at the grade 5 level departmentalized science instruction with specialized teachers begins. Physics fundamentals are initiated at grades 6 and 7, and further developed in grades 8 to 10. Chemistry starts at grade 7, and biology at grades 5 and 6. Arithmetic commences in the primary grades, and develops into algebra and geometry (grades 6 to 10) and trigonometry (grades 9 to 10).

In the United States, science instruction usually does not start as a separately organized subject before grade 7. Typically, only a single year of a given science subject, biology, physics, chemistry, will be given through grade 12. In mathematics, instruction is usually available through algebra, solid geometry, and trigonometry.

The standard curriculum of the U.S.S.R. assumes that all students of a particular type of school will be provided instruction in the same subject matter. The comprehensive high school in the United States offers numerous curriculums to meet varying student interests, including academic, vocational, commercial, etc. As one result, only the academic curriculum approaches the Soviet emphasis on science and mathematics at the secondary school level. Only about one-quarter of the U.S. high school graduates will have studied physics and less than 10 percent solid geometry and trigonometry.

Comparing the extent of the school curriculum devoted to science and mathematics in the two countries must take into account such differences as the length of the school week, number of years involved, years in which specialized instruction is provided, and the nonstandardized character of U.S. training. In the secondary school comparison shown below, instruction hours are shown

for grades 5 to 10 of the standard U.S.S.R. 10-year school and for a strong college preparatory course in a good U.S. 4-year high school.

Subject	U.S. high school (4 years) college preparatory		U.S.S.R. grades 5 to 10 (6 years) standard curriculum	
	Hours	Percent	Hours	Percent
Total	2,974	100	6,653	100
Mathematics	612	20	1,207	18
Science	612	20	1,662	25
Native language	700	24	1,215	18
Foreign language	350	12	680	10
Social studies	350	12	593	9
Vocational and other	350	12	1,302	20

Sources: NSF and U.S. Office of Education.

This comparison showing total instruction hours of 2,974 for the United States and 6,653 for the U.S.S.R. should not be interpreted as meaning that Russian youth attend school twice as long as their American counterparts. Rather the comparison is based on secondary school curriculums which cover 6 years of 6 days per week in U.S.S.R. and 4 years of 5 days per week in the United States. When elementary schooling—4 years in U.S.S.R. and 8 years in the United States—is added, the total school hours through secondary levels is about the same.

In general, the stress on science and mathematics is considerably greater in Soviet than in American schools. Specialized instruction in science begins earlier there and continues for a larger proportion of students. An "average" Russian 10-year school graduate will have had a much greater amount of instruction in chemistry, physics, biology, and mathematics than an equally mythical, and harder to define, "average" American high school graduate. Since the preceding table is based on comparing the instructional hours received by an American student enrolled in a strong "academic" or "college preparatory" course with the commonly offered program in the U.S.S.R. 10-year schools, it is apparent that an even greater contrast would appear if one were to compare "average" graduates of the two kinds of schools. On the other hand, it is also clear that one should not conclude that, because physics, say, is taught over a period of 5 years in Soviet schools, students there receive five times as much instruction in this subject as in our own schools. Considering the fact that some preliminary instruction in physical science is included in the pre-high-school program in many American schools, and remembering that the Russian system may in some years devote only 2 or 3 hours per week to instruction in physics, it turns out that the Soviet student may receive only about twice as many hours instruction in this subject as would those American students who elect to take physics in high school. Hence, to say that Soviet students receive instruction in physics for about twice as many hours as American students is more accurate and meaningful than to say that the schools in the U.S.S.R. offer 5 years of instruction in physics whereas American schools offer only 1.

Since the total instruction hours in the comparison differ so greatly, relative curriculum emphasis can be better compared in terms of the percentage of instruction time devoted to the several subject fields. On this basis, for a U.S. student in an academic or college preparatory program who elects 3 to 4 years of science and 3 to 4 years of mathematics, the hours devoted to mathematics and science in the United States account for 40 percent of the total, and in the U.S.S.R. for 43 percent. The United States emphasizes native language (24 percent) more than the U.S.S.R. (18 percent) and foreign language hours are about the same in both countries. Social studies account for proportionally more instruction hours in the United States (12 percent) than the 9 percent in the U.S.S.R., although not greatly so. Considerable differences show in the "vocational and other" category with a U.S.S.R. percentage of 20 and a U.S. percentage of 12. (Since U.S.S.R. vocational training is strongly oriented toward technology, this tends to increase the science and mathematics emphasis.)

This comparison demonstrates that relative curriculum emphasis in the two countries at the secondary school level is not greatly different between the U.S. strong college preparatory course and the U.S.S.R. standard 5 to 10 year school curriculum. However, there is a very real difference between the commercial,

business, or vocation courses in the U.S. and the U.S.S.R. curriculum. U.S. courses of this type carry relatively small emphasis on science, mathematics, or foreign language.

U.S. elementary and secondary school curriculums in science and mathematics

Unlike the situation in many other nations, no "national curriculum" exists in the United States. The responsibility for curricular planning and development rests primarily with the local unit and in some subject areas with State educational agencies. Curricula formulation is affected or influenced by local or national opinion, but there is no one individual or agency responsible for overall, national standards. Hence, any generalized statement is apt to be misleading—the exceptions may be as numerous as the typical instances. The range of curriculums in the U.S. elementary and secondary system is very great but it is a range adapted to local conditions and attitudes. Nonetheless, despite the apparent diversity of approaches, the American secondary school system provides a surprisingly constant educational product.

Exposure to scientific and quantitative concepts in the U.S. educational system begins as early as the first grade. Many elementary schools have—or are developing—curriculums which include instruction in various aspects of science, and most school curriculums are designed to give the child an awareness and appreciation of science. Arithmetic is given to nearly all elementary students from the first grade on, and in some schools the brighter pupils are studying algebra and geometry by the seventh and eighth grades.

In most elementary schools science is taught by the classroom teacher who is also responsible for teaching the other basic subjects; there is no effort, in most cases, to develop a "course" in science at this early school age. The area of study is most frequently suggested by a textbook or a curriculum guide. The typical elementary classroom teacher is not well prepared to provide specialized instruction in science or mathematics. Teacher training at this level concentrates on pedagogy and language skills; the teacher's preparation in science and even elementary mathematics is likely to be deficient. In a small number of elementary schools, usually the larger urban systems, there is a trend toward departmentalization of science teaching—leading to the introduction into the system of specially trained teachers of science in a manner analogous to the well-established plan for the use of special teachers of music in vogue already in a number of systems.

In secondary schools the offerings in science and mathematics are more formalized, in terms of subjects to be studied, than is true for elementary schools. The standard courses in science are general science, biology, chemistry, and physics; in a number of schools some instruction is given in astronomy, geology, and other fields. In mathematics, the usual courses offered are beginning algebra, plane geometry, intermediate algebra, solid geometry, and trigonometry. The tabulation below presents the ratios of the number of students enrolled in a particular science or mathematics course to the total enrollments in the grade at which the course is typically taken.

Courses in U.S. high school	Typical grade level	Percent of pupils enrolled of total in grade
General science	9	67.0
Biology	10	75.5
Chemistry	11	34.6
Physics	12	24.3
General mathematics	9	43.1
Elementary algebra	9	67.0
Plane geometry	10	41.6
Intermediate algebra	11	32.2
Plane trigonometry	12	9.2
Solid geometry	12	7.6

Source: U.S. Office of Education.

It will be seen from the foregoing data that only two science courses and one mathematics course represent the typical training of American high school graduates. Only about one-third of the students take chemistry and one quarter, physics. In mathematics, about one-third are found in intermediate algebra, but less than 10 percent study trigonometry or solid geometry. Since 3 or 4 high

school units* in science and 3 or 4 in mathematics are recommended as prerequisites for collegiate training in science and engineering, many high school graduates find their opportunities for undertaking professional work in these fields foreclosed or severely diminished before even applying for college.

Elementary and secondary school curriculums in the U.S.S.R.

The U.S.S.R. follows the practice—a common one in many countries—of having a standard curriculum in its general education structure; this is to say that all students as they progress through elementary and secondary school generally take the same subjects. There are some variations between urban and rural schools, for purposes of allowing participation in agricultural work, and variations for other minor purposes. In the main, unlike the U.S. system where determination of curriculum is on a State or local basis, and students have some latitude in choice of subjects, students in the U.S.S.R. all receive the same amount of instruction in basic subjects.

The U.S.S.R. curriculum has been strongly oriented toward science, engineering, mathematics, and vocational subjects. In 1957, it is estimated that about 30 percent of instruction hours in the 10-year schools were devoted to scientific topics. Furthermore, a substantial part of the time devoted to vocational topics was similarly oriented in view of the U.S.S.R. emphasis on vocational training in technical subjects. Below are presented curriculum comparisons for the pre-reform and proposed post-reform complete secondary schools.

Area	U.S.S.R. 10-year school, 1957 curriculum		U.S.S.R. 11-year school, 1963 curriculum (proposed)	
	Instruction hours	Percent	Instruction hours	Percent
Total	10,617	100	12,828	100
General (language, literature, humanities, social sciences)	4,692	44	4,884	38
Scientific (sciences and mathematics)	3,332	31	3,727	29
Applied activities and vocational skills	2,593	25	4,217	33

This comparison indicates an even greater emphasis in the future on scientific and technical subjects. The net effect of the additional school year will be to increase instruction hours in all these fields, but the expansion in the scientific and vocational (largely technical) will be about one-third.

U.S.S.R. EMPHASIS ON EDUCATION

Dr. WATERMAN. One key fact to remember is that those who have shown aptitude for science and engineering are strongly encouraged in a variety of ways to go into these fields. Therefore, they do not lose their good people. There is no reason why they should, since they can assign them. This creates for the United States a pretty stiff type of competition—certainly, in the short range.

With our system we know we are losing some people who have this aptitude, people who do not go on into higher education at all; and then we know too that the American people in general do not hear very much about science, and that means that our national appreciation of the significance of science is not as great as it should be. Our people are simply not as well informed with respect to science and technology as they ought to be for the long run welfare of the country. But, the chief consideration, of course, is that between the elements of compulsion in Russia and the rewards of going into science or engineering as a career—and these are very high—they are succeeding

*A "unit" represents the study of a given subject, or "course," 5 days per week for a full school year of approximately 35 weeks.

in getting a very determined effort on the part of the whole Nation to enter this field strongly. They have made remarkable progress. There is no denying that. So, where we come out is that we should make a determined effort ourselves—not simply in the sense of trying to compete with them where they have achieved something spectacular, but we must take the initiative, which we can do, and develop our own skills to a maximum.

Then, and only then, can we achieve continuing leadership, but it will take an increasing amount of attention, effort and resources.

Mr. THOMAS. Does anyone have any specific information as to what happens to Russian students? Can you start with the high school level, and then go to the college level under the compulsory system where it is paid for, and so forth? And then, what becomes of the persons who are not quite able to make the high marks that are required for university training? In other words, what happens to him? Are you able to address yourself to that general subject at this time, Dr. Kelly?

Dr. KELLY. Yes, sir; the particular point you raised of the transition between the high school or 10-year school to college——

Mr. THOMAS. Take the entire field.

Dr. KELLY. After the 10-year school, not all of the graduates are able to get into the Russian colleges (or "institutes") and universities; however, they are building more institutions of higher learning so that increasing numbers can be admitted in the future. A student who finishes the 10-year school can make application to a single department at a single university. If he does not succeed in getting accepted, he has a choice of going into one of the technical schools. These are technical schools for lathe operators, machinists, farmers, and the like. He also has an opportunity of going to work in a factory or on a farm where he can go to school in the evenings or on weekends. Such workers are given some time off to continue their education.

At our appropriation meeting last year, Mr. Boland asked me to comment on this and I tried to make two points: First, everyone we met in Russia is convinced of the importance of education and is dedicated to the task of developing their educational system; second, there is a general conviction among the Russians that they can beat the United States technically, economically, culturally, and militarily. They believe that school training is needed to meet these needs. I think it is folly not to believe that they mean this.

Dr. WATERMAN. Mr. Chairman, you may remember that Dr. Kelly himself spent a month in Russia a little more than a year ago.

Dr. KELLY. Yes, sir. My observations there lead me to feel that we should have apprehensions not about them but about ourselves—as to whether we have our own goals in mind as clearly as the Russians have theirs. Their material goals are clear and they believe the future is promising. They have the natural resources and they have the conviction that although they have to suffer and work hard now, their children will have it easier, as far as material things are concerned. They work as our pioneers did in this country.

Mr. THOMAS. May I interrupt you a minute?

Dr. KELLY. Surely.

Mr. THOMAS. We all realize that what makes the Russians dangerous is this: They are building on the most solid of all known foundations. That foundation is education.

Dr. KELLY. I thoroughly agree, Mr. Chairman.

FINANCIAL SUPPORT OF STUDENTS

The subject of financial support of college and university students was mentioned a few minutes ago. While there is not a great deal of difference at the elementary and secondary levels in the two countries—since such schools are largely supported by public funds in both cases—real differences begin to show up at the postsecondary level. In the United States more than half of the college students attend public institutions and pay nominal tuition and other charges in addition to maintaining themselves. The remaining students attend private institutions where the costs to individual students are substantially greater. A good many students in both types of colleges receive scholarships and other kinds of supplemental support which help to pay their expenses. But the main responsibility is on the student, himself, or on his family. In Russia the attendance at an institution of higher education is tuition free, and for a large share of the students—about 80 percent, if I remember correctly—a State stipened is granted which meets such expenses as board, lodging, and books. The U.S.S.R. has to limit the number of students who can be supported, and the quality of students who gain admission is very high. In the United States, we make an effort to provide classrooms for all reasonably well qualified applicants.

A much higher level of support is provided for our graduate students than for those at the undergraduate level. In addition to funds for stipends for research assistants provided through Federal and other research grants, several Federal agencies administer fellowship programs. I have an estimate that for fiscal year 1960 about 6,000 graduate students (mainly in science and related fields) will be supported through fellowships by National Institutes of Health, the National Science Foundation, the Atomic Energy Commission, the U.S. Office of Education, and others.

Dr. WATERMAN. I do not think that we can say categorically that the Russian system of student support is better than ours just because college and university students are fully subsidized. No doubt there are losses of good talent in both countries. In Russia the higher educational system apparently cannot accommodate all who would like to attend. In this country, where most students at the undergraduate level must provide for a large part of their support, there is no doubt that some highly capable youth cannot attend college because of lack of funds; others because of lack of interest or motivation. Estimates of the numbers involved vary greatly. What concrete evidence we have, however, seems to indicate that our loss at the highest ability levels may not be as great as we have thought in the past. At the graduate level there are mechanisms for support of high-quality scholars through fellowships, research assistantships, and in other ways. We can watch this situation carefully and provide for additional support when it appears that graduate education is suffering through inadequate funds for student support. It is

hoped that lack of motivation toward higher education may be overcome by realization of the ultimate advantages for these who can qualify.

Mr. THOMAS. These are interesting observations, Dr. Waterman. Will you have something more on this general topic for the record?

Dr. KELLY. Yes, sir. We shall be glad to prepare material.

(The information requested follows:)

THE ALLOCATION OF EDUCATIONAL COSTS

Differences in basic social and political philosophies in the United States and U.S.S.R. are nowhere more striking than in the approach to bearing the costs of education. Both countries profess their belief in the education of the mass of the population to a certain point, which is reached at a somewhat later age in the United States than in the U.S.S.R. Beyond this point, education in the United States is more of an individual matter depending upon the student's interest, vocational choice, and ability to secure necessary financial resources. In the U.S.S.R. higher education is the state's concern. The state determines the number to be trained to meet estimated needs. It then controls the machinery to make certain that the predetermined number is trained.

Education in the United States is an accepted public responsibility through the secondary school level, and the children attending privately supported schools up to the 12th grade are relatively few (about 12 to 15 percent). Through this level, educational costs are borne almost entirely by the taxpayers through local and State taxes. Similarly in the U.S.S.R., elementary and secondary education is a public matter and is provided through the resources of the Soviet State.

At the higher education level, the differences become more apparent. More than half of the U.S. college students attend public institutions where the usual practice is to charge at least nominal fees or tuition. For the balance of the students—those attending private colleges and universities—educational costs become substantial. In the U.S.S.R., not only is instruction at institutions of higher education free, but in upward of 80 percent of the cases a state stipend is granted which meets such expenses as board, lodging, and books.

Costs of higher education in the United States are shared among—

(*a*) the student and his family;

(*b*) the institution, which may subsidize the student through its endowment resources or provide outright scholarship support; and

(*c*) the taxpayer who provides support for the public institutions.

In the U.S.S.R., costs are state financed, which is to say, they are a charge upon the workers in the civilian economy. To a minor extent, costs will be borne by the student and his family, where stipend support is not requested or secured.

The Soviets fix the number of students who can be admitted to each institution of higher education, and then select the entrants through a severe examination process. In this way educational resources are geared to estimated needs for trained personnel, and the entrance process is designed to assure the continued training of only the ablest students. About 30 percent of those seeking admission to institutions of higher education are admitted as regular full-time students. Some opportunities are, however, available to others through correspondence study and less formal educational programs.

U.S. educational philosophy holds that each person should develop his potential so far as he is able and in accordance with his individual interests. This permits the student to seek the curriculum of his choice, and so influences the colleges and universities to establish courses of study for which a demand develops. Since higher education then becomes largely an individual matter, primarily existing to meet the student's desires, it does not seem unreasonable that the individual student is called upon to meet the major share of the cost. The unfettered development of the individual in this way is considered, in the aggregate, as the most effective way of meeting the needs of a democratic nation for a well-educated citizenry.

THE SCIENTIFIC AND ENGINEERING LABOR FORCES IN THE UNITED STATES AND U.S.S.R.

Dr. WATERMAN. We have talked about the numbers in school and the numbers studying science in the two countries. You asked also,

Mr. Chairman, for some information about the numbers of scientists we have at the various levels of education as compared with the Russians. Dr. Kelly now has some information on this subject. Is this the time to bring it in?

Mr. THOMAS. We are very much interested in this, Dr. Kelly. Go ahead.

Dr. KELLY. Comparisons between such different kinds of educational structures are both difficult and risky. Although the same terms are often used, their meaning may be quite different. We have about 2,000 institutions of higher education of various types—about 500 2-year community or junior colleges, and approximately 1,400 degree-granting schools, including our large and complex universities and technological institutions. The Russians have about 750 institutions of higher education—also of several types. Differences between the two countries in what is considered to be professional qualification are considerable. For example in the U.S.S.R., medical graduates—practitioners—usually have 6 years of training beyond the 10-year school. Graduates in education for elementary and secondary school teaching have had only 2 years. (However, the U.S.S.R. is now moving to abolish the 2-year teacher training institutes in favor of 4- and 5- year pedagogical schools.) On the other hand, medical students in the United States have 7 or 8 years of training plus internship—this in addition to the 12-year elementary and secondary school training. Most teachers in the United States now complete a 4-year course, and some of them 5 or 6. There are now in the United States only a handful of 2-year normal schools for teachers, and they are disappearing rapidly. In contrast, the engineering diploma in the U.S.S.R. represents a 5-year period of study beyond the secondary level where the usual engineering training in the United States is 4 years—but this is changing in some places in the United States now to a longer course, quite often with more stress on the humanities and the social sciences.

Altogether, we have about 8 million or more who have completed college training, while the Russians have under 4 million; but there has been a wide difference in emphasis with respect to fields. In Russia, planning by the State has led to heavy emphasis on agriculture, education, engineering, and the sciences. In the free choice system of the United States the largest numbers of graduates have been in education, business, commerce, and the social sciences. The proportion of our graduates in science and engineering as a whole has been far below that of the Russians. At the same time, our free choice system has been quite responsive to demand as represented by employment opportunities.

Mr. THOMAS. How do our bachelor's degree graduates now compare with the Russians?

Dr. KELLY. We award about 30,000 to 40,000 more bachelor's degrees per year than the Russians do. But about one-third of their graduates are in engineering, compared with about 10 percent of ours.

Mr. THOMAS. This makes the picture much more clear, Dr Kelly. But you have given us a great many figures. Can you summarize what you have just said in two or three sentences?

Dr. KELLY. The main points, I believe, are these. We have about twice as many college-trained people as the Russians, but ours are trained over a large number of fields while the Russians have emphasized science and technology more than we have. In Russia, specialization by individual students is influenced by state planning; in the United States, students have fairly complete freedom of choice in what they will study. While we are producing 30,000 or 40,000 more bachelor's degree graduates per year than the Russians, they are graduating approximately three engineers to our one. The Russians have about a million trained engineers, compared with about 850,000 in this country. We apparently are at present ahead of the Russians in the number of Ph. D.-level scientists and engineers—particularly with respect to the physical sciences. In general, I think we may say that at the moment we are slightly ahead of the Russians in terms of scientific and technical manpower, but the margin is narrow and we must keep up steady and sustained pressure for both quality and quantity if we are to maintain superiority.

Mr. THOMAS. Will you have a more detailed statement on this for the record?

Dr. KELLY. We have information on these topics which is rather technical but could quite easily be put in summary form and submitted for the record. Some of it will be published later in a forthcoming revision of "Soviet Professional Manpower," by Mr. Nicholas DeWitt. Mr. DeWitt has generously made some of his research available to the Foundation prior to publication.

Mr. THOMAS. Thank you, Dr. Kelly.

(The information requested follows:)

COLLEGE AND UNIVERSITY TRAINING IN THE UNITED STATES AND U.S.S.R.

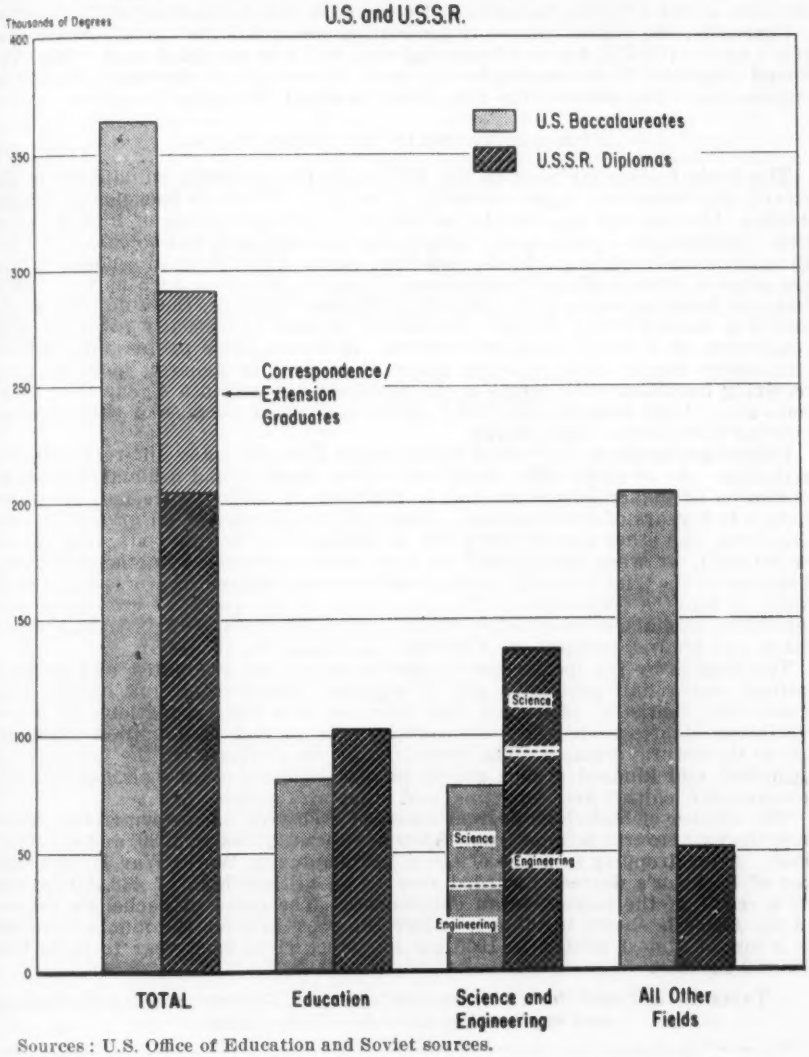
Post-secondary school training in both countries is carried out in a system of institutions of higher education. In the United States there are nearly 1,400 college-level institutions which grant a bachelor's degree (usually after a 4-year course). Each one of these institutions has its own curriculums and within a system of voluntary accreditation certifies a student for the award of a bachelor's degree. These degree-granting institutions—which include large complex universities, liberal arts and teachers colleges, and various professional schools—are supplemented by about 500 community or junior colleges and technical institutes which provide either 2-year terminal training or the first 2 years of degree credit curriculums. However, in the U.S.S.R., students at corresponding levels attend a number of different types of higher education institutions ranging from 6-year medical institutes to 2-year teachers institutes—although these latter are being replaced by 4- and 5-year pedagogical institutes. The total number of higher educational institutions is about 750. Students trained in these various types of schools follow standardized curriculums and receive diplomas (but not degrees) upon completion.

It can be misleading to attempt to compare the typical college graduate in the United States with his nearest counterpart in the U.S.S.R., for the corresponding courses of study are not strictly comparable in terms of length or emphasis of training; this is particularly true in the fields of education and medicine. U.S.S.R. medical graduates (corresponding to our M.D.'s) in general receive 6 years of training beyond the 10-year secondary school—but education graduates 2 to 5 years. In the United States, medical graduates receive on the average 7 or 8 years of training plus internship after a 12-year period of elementary and secondary school. Most teachers in the United States have completed a 4-year course (many have 5 or more years) beyond graduation from high school. On the other hand, the engineering diploma in the U.S.S.R., represents a 5-to 5½-year period of training beyond the 10-year school in contrast with the general 4-year curriculum after 12 years of elementary-secondary school in the United States.

HIGHER EDUCATION GRADUATES

Number of Bachelor's Degrees and Diplomas Awarded, in Selected Fields, 1958

U.S. and U.S.S.R.



Sources: U.S. Office of Education and Soviet sources.

The educational systems of the two countries have been developed along very different lines, and comparisons between them must be viewed—at best—as rough approximations which, improperly interpreted, might lead to serious misunderstanding. Gross comparisons between diploma holders in the U.S.S.R. and baccalaureates in the United States should be interpreted as numbers who have reached certain terminal points in two different systems without any assurance that a similar level of training has been either sought or attained.

Recent data for the two countries show that (as of 1959) about 8.3 million persons in the United States had graduated from college compared with about 3.7 million persons in the U.S.S.R.—at least 2 million of them since World War II. A main difference between the two countries lies, however, in the emphasis on fields of training. In the U.S.S.R., emphasis has been placed on training in such fields of agriculture, engineering, education, and the sciences. In the United States, selection of field of training is a matter of choice of individual

students, taking into account their abilities, interests, economic and social opportunities, etc. This has resulted in the principal fields of study of graduates at the bachelor's degree level being education, humanities and arts, natural sciences, social sciences, business and commerce, and engineering in that order.

Currently, the United States is graduating about 375,000 baccalaureates per year; in the U.S.S.R. about 340,000 diplomas are now awarded each year. The Soviet emphasis is shown in the one-third proportion of diplomas granted in engineering. The comparable U.S. figure is about 10 percent.

HIGHER EDUCATION IN THE UNITED STATES

The basic college training in the United States generally culminates in the award of a bachelor's degree—usually a bachelor of arts or bachelor of science degree. Degrees are awarded by several types of institutions of higher education—universities, liberal arts colleges, teachers colleges, technological schools, theological and religious schools, and other types of professional schools. There are several other kinds of institutions of higher education such as community colleges, junior colleges, and technical institutes; however, these do not usually award a baccalaureate degree. Bachelors degrees are usually awarded upon completion of a 4-year academic course. However, some professional schools and others require five or more years of study. In general, most students receiving baccalaureates complete the requirements within a 4-year time span; some exceptional students finish in 3 years; and others, because of part-time and evening attendance, take longer.

College graduates in the United States can be found in many different economic activities. As of early 1959, about 8.3 million persons had graduated from an instiution of higher education, and in addition 10 million more had completed from 1 to 3 years of such training. Nearly three-quarters of all graduates were employed; the other quarter were not in the labor force (students, housewives, or retired), or were unemployed (a very small number). Furthermore, over 4 million of the 6 million employed graduates were engaged in professional, technical, or kindred occupations. The remainder of the employed graduates were managers, officials, or proprietors of various organizations (900,000), in clerical, sales, and kindred occupations (760,000), or other jobs (370,000).

Teaching is by far the largest occupation of college graduates, and nearly a million and a half graduates are so engaged. Engineering and health fields (medicine, dentistry, pharmacy, and nursing) are the occupations of nearly 600,000 graduates each, while approximately a quarter of a million graduates are in the natural sciences. The remainder of the graduates in the professional, technical, and kindred groups are in such occupations as law, social sciences, accountancy, editing and reporting, and other professions.

The number of bachelor's degrees awarded each year has grown tremendously over the past several decades from 48,600 in 1920 to 122,500 in 1930, and 186,500 in 1940. After dropping to a low of about 140,000 during World War II, the number of bachelor's degrees awarded rose to an alltime high of 433,700 in 1950 as a result of the large veteran enrollments. The trend of bachelor's degrees in the 1950's is shown in table 1. After the peak in 1950, the number dropped to a low of almost 290,000 in 1955 but has since risen each year to more than 365,000 in 1958.

TABLE 1.—*All bachelor's degrees and bachelor's degrees awarded in science and engineering, 1950–58—United States*

Academic year	Number of bachelor's awarded		Percent natural science and engineering of all bachelor's
	All bachelor's	Natural science and engineering	
1950	433,734	108,784	25.1
1951	384,352	88,465	23.0
1952	331,924	68,206	20.5
1953	304,857	57,531	18.9
1954	292,880	53,497	18.3
1955	287,401	53,359	18.6
1956	311,298	61,327	19.7
1957	340,347	70,178	20.6
1958	365,748	77,785	21.3

Source: U.S. Office of Education.

Bachelor's degrees awarded are expected to continue this increase in the future. Based on population trends and projected ratios of college attendance, the number of bachelor's degrees awarded will probably exceed 400,000 in 1960, and 700,000 in 1970.

The number of bachelor's degrees awarded in engineering and the natural sciences, while increasing much faster than degrees in all fields in the 1920's and 1940's, has remained at a fairly constant proportion of the total in the 1950's (around 20 percent). As may be seen by table 1, the number of degrees in these fields dropped from a total of 109,000 in 1950 to about 53,000 in 1955 and then rose to nearly 78,000 in 1958. If it is assumed that degrees in science and engineering will remain at current proportions of all bachelor's degrees, the number awarded in these fields may rise to over 85,000 in 1960 and over 150,000 by 1970.

As mentioned above, more than 365,000 bachelor's degrees were awarded in 1958. Table 2 shows a distribution of the major fields of these graduates. Education is the field of the largest number of graduates; sciences and engineering together number about 78,000 (engineering alone shows over 35,000 degrees), and the social sciences and humanities accounted for 49,000 and 48,000, respectively.

TABLE 2.—*Number of earned bachelor's and first professional degrees by broad field, 1957–58—United States*[1]

Field	Bachelor's degrees	
	Number	Percent
Total	365,748	100.0
Natural sciences	77,785	21.3
Agricultural sciences (including forestry)	6,769	1.9
Biological sciences	14,408	3.9
Engineering	35,332	9.7
Mathematics	6,924	1.9
Physical sciences	14,352	3.9
Science, general program	1,892	.5
Psychology	6,930	1.9
Social sciences (includes anthropology and geography)	49,005	13.4
Fine arts and humanities	47,801	13.1
Education	82,892	22.7
All other	101,335	27.6

[1] This classification of degrees includes 1st professional degrees in such fields as medicine, dentistry law, and theology.

Source: U.S. Office of Education.

HIGHER EDUCATION IN THE U.S.S.R.

The basic higher education level training in the U.S.S.R. is provided through attendance at higher educational institutions of several types. Included in the higher education institutions are medical institutes with 6 year training, engineering institutes or universities with a 5–5½ year course, agricultural, pedagogical, and socioeconomic institutes with 4 years of training, and teacher training institutes with 2 years (now in process of being replaced by 4- and 5-year pedagogical institutes for elementary and secondary school teacher training, respectively). Students successfully completing courses from these higher education establishments receive diplomas. (Clearly the U.S.S.R. diplomas and the U.S. baccalaureates are not—in general—closely comparable, although they are frequently compared as arbitrary measures of educational progress in the two countries.)

As of January 1959, there were more than 3.7 million persons with diploma level training in the U.S.S.R. and slightly over 3 million of them were employed

in the civilian economy. The following tabulation indicates the field of training of about 2.8 million of these persons as of January 1958:

Field	Number of persons	Percent	Field	Number of persons	Percent
Total	2,805,500	100	Engineering	816,100	29
			Law	57,800	2
Agriculture	193,100	7	Medicine	346,000	12
Economics	157,500	6	Others	90,100	3
Education [1]	1,144,900	41			

[1] Includes an estimated 125,000 trained in mathematical, physical, and biological sciences.

A comparison with similar data for 1941 indicates, that, while all fields have more than doubled, the sharpest expansion has been in education and engineering.

These diploma level personnel are employed in many sectors of the civilian economy of the U.S.S.R. Table 3 shows a distribution of these persons for January 1958 by type of employment. It will be seen that those comprising the largest single group are employed in educational institutions.

TABLE 3.—*Employment of personnel with bachelor's degree level of training (or higher) in the general branches of the U.S.S.R. civilian economy, January 1958*

Type of employment	*Number employed*
Total	2,805,000
Agriculture (Kolkhozes [collective farms] and machine tractor stations) [1]	71,000
Agriculture (Sovkhozes [state farms] and subsidiary enterprises)	32,000
Construction organizations	62,000
Educational institutions: cadre training institutes, general education schools, cultural-educational institutions	1,138,000
Health institutions	307,000
Industrial enterprises	354,000
Scientific and scientific research institutions including planning, designing, and geological survey organizations	356,000
State and economic administrative organs; administrative organs which manage cooperative and public organizations; credit and insurance institutions	255,000
Trade, public feeding establishments; procurement, materials and technical equipment supply	32,000
Transportation and communications	56,000
Others (designation unknown)	142,000

[1] Machine tractor stations have been virtually abolished; their personnel were redistributed throughout other sectors of the agricultural economy.

A large proportion of the persons in the U.S.S.R. with diploma level training completed this training after the end of World War II. The following tabulation illustrates annual diploma level graduations in various fields in the last few years.

Field	1957	1958	1959
Total	266,500	290,700	340,000
Agriculture	29,800	30,900	34,000
Economics and law	20,200	24,000	21,000
Education	109,200	116,200	149,000
Engineering	83,100	93,600	106,000
Medicine	24,200	26,000	30,000
Physical, biological, and mathematical sciences	12,000	13,000	14,000

Training at the diploma level in the U.S.S.R. is strongly oriented toward engineering and scientific fields. In 1958, nearly 30 percent of those trained at this level and employed in the civilian economy held diplomas in engineering. Recent graduating classes have been nearly one-third engineering diplomas. While the emphasis on natural science is somewhat obscured by the classification system by which diplomas are reported, it appears that nearly 25 percent of the current diplomas awarded in the U.S.S.R. are in fields considered in this country to be either natural science or medicine.

A considerable number of those receiving diplomas from the U.S.S.R. higher educational institutions have been correspondence or evening school students, many of them employed full time while taking course work. Recent enrollment data indicate that over 45 percent of all students in higher education are in correspondence, extension, or evening courses. About 15 percent of the engineering graduates of 1959 in the U.S.S.R. were correspondence or extension students.

Engineering Manpower

Engineering is an extremely important occupation in both the United States and the U.S.S.R. Numerically, it is one of the largest professional fields. Economically, it is important in development and the application of scientific techniques to production.

The U.S.S.R. currently has nearly 1 million professionally trained engineers, typically with at least a 5-year engineering institute diploma. About 25,000 of them hold the Kandidat (considered equivalent to our Ph. D.) degree. Engineers in the United States numbered about 850,000 in 1959, and perhaps a third or more of them did not possess a formal academic degree, having attained professional status through experience, self-study, or other training.

Currently, the U.S.S.R. is outproducing the United States in engineering graduates at a rate of approximately 3 to 1. Soviet plans call for further expansion of training in this field to produce an average of 125,000 per year in the period 1959–65. The U.S. rate of graduation of first-degree-level engineers is presently at a level of about 38,000.

The contrast between the two systems is especially clear in the approach to engineering training. In the U.S.S.R., a determination of how many engineers should be trained in each field is made centrally, based upon anticipated requirements. Training institutions are informed, and quotas are set in accordance with anticipated requirements. Entrance examinations screen out the surplus applications. In the United States, enrollments are determined by a complex of factors; some of the major components are the free vocational choice of students, the competitive attraction of other professional occupations, the costs of training, the training facilities available to the student, current information regarding "demand" (by field), and other similar factors interacting with those mentioned and with each other.

It is by no means clear how effective the Soviet system is in meeting its problems of training engineers in the numbers and with the qualifications desired; the Soviet press on occasion has been critical of its results. Weaknesses of this system appear to arise from the specialized character and lack of flexibility in training for specific jobs; the impossibility of predicting scientific developments which create new and novel requirements; the dependence upon extension and correspondence school training; and malutilization of the trained specialist for which a specialized position cannot be found. All of these difficulties are, of course, in addition to the frailties of the human mind in dealing with problems of complicated economic and social variables.

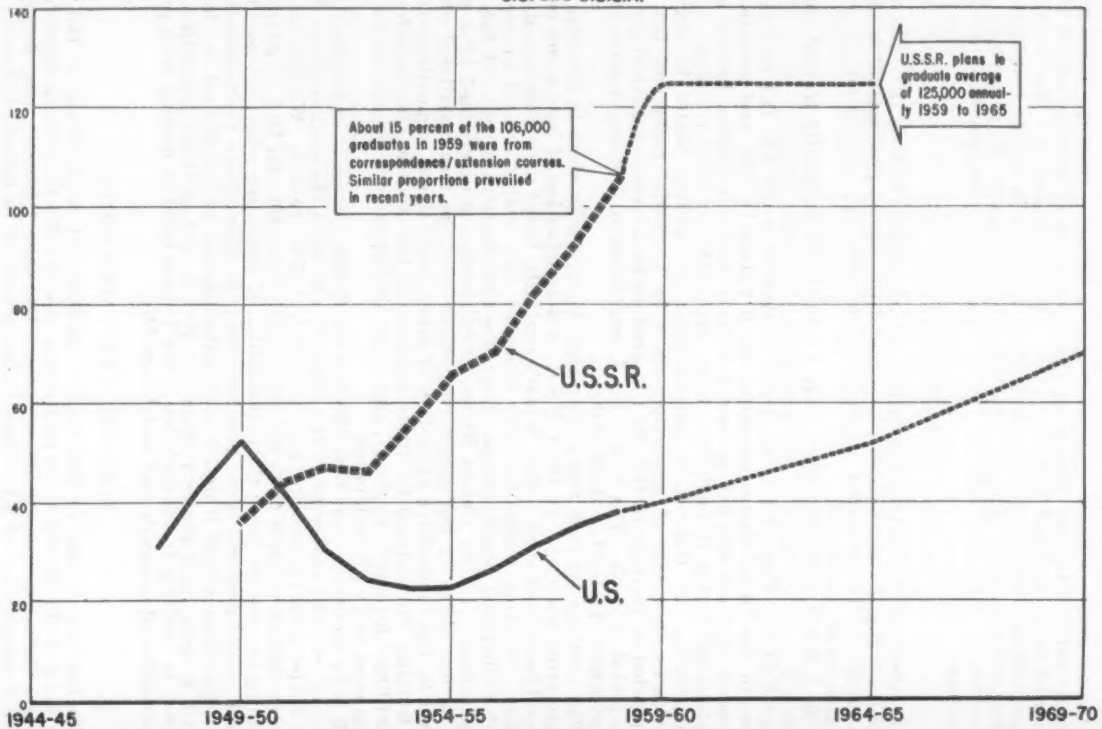
Engineers in the United States

Engineering is one of the largest professional occupations in the United States; it is the largest male profession. As of 1959, there were approximately 850,000 employed professional engineers; less than 1 percent were women. Almost three-quarters of all engineers are employed in private industry; nearly every manufacturing industry employs some, with the largest numbers being in electrical equipment, aircraft, machinery, motor vehicles, transportation and other public utilities, construction, chemicals, petroleum, and telecommunications. Those comprising the next largest group of engineers are employed by Federal, State, and local government agencies—probably more than 15 percent are so engaged. Other sectors employing engineers are engineering and architectural services, educational institutions, commercial laboratories, and nonprofit organizations; about 5 percent are on active duty in the Armed Forces.

HIGHER EDUCATION GRADUATES IN ENGINEERING

Number of Bachelor's Degrees or Diplomas Awarded 1948 to 1958 and estimated to 1970

U.S. and U.S.S.R.



Sources: Office of Education and Soviet sources.

Civil, mechanical, and electrical engineering are the largest of the major branches of the engineering profession; they are followed in size by industrial, chemical, aeronautical, and mining and metallurgical.

Four years of college work leading to a bachelor's degree in engineering are usually the minimum educational requirement. Some persons enter the profession with training in physics, chemistry, mathematics, or related fields. Others have reached professional status in this occupation without a degree, but usually after considerable experience as a technician or in other semiprofessional work. Many of these persons have considerable academic training although short of a bachelor's degree. The proportion of engineers with advanced degrees, though small, has been growing rapidly; with 5,768 master's degrees granted in 1957–58, it was outranked only by education and with 647 doctorates granted in the same year, it was outranked only by education and chemistry.

Some 226 universities and engineering schools offered training leading to a bachelor's degree in engineering in 1957–58; more than 150 of these schools had curriculums which were accredited by the Engineer's Council for Professional Development. This organization, a private professional group, reviews and accredits each separate curriculum for major engineering courses of study at institutions offering bachelor's degree level training. Both the qualitative and quantitative effort of training is considered. Most engineering curriculums are set up on a 4-year basis with the first 2 years devoted to basic sciences, preengineering subjects, and to other courses such as social sciences, humanities, and English. The last 2 years are devoted generally to specialized engineering courses and to advanced mathematics and science. Some institutions have 5-year programs leading to a bachelor's degree; some engineering schools have arrangements by which 3 years in a liberal arts or other school are combined with 2 years of engineering resulting in a bachelor's and a first professional degree. A few schools have a cooperative arrangement under which students alternate attendance at college and employment in industry or Government; these arrangements are usually spread out over a 5- or 6-year period.

Engineering enrollments and bachelor's degrees over the last decade are shown in the accompanying table (table 4). In both cases, post-World War II peaks were reached about 10 years ago owing to large enrollments under the GI bill. After dropping in the mid-1950's because of a decline in population of college age and a decline in the number of veterans in school, enrollments and degrees again increased through 1958. In both 1959 and 1960, engineering enrollments declined, although degrees granted are still increasing. To some extent, the decline in engineering enrollments was apparently offset by an increase in science students. In view of the trend of increasing college-age population in the next 10 to 15 years, the engineering enrollment decline appears temporary, and such enrollments and degrees can be expected to increase again in the near future.

TABLE 4.—*Engineering enrollments and degrees at the undergraduate level, 1948–49—1958–59—United States*

Academic year	Undergraduate enrollments	Number of degrees	Academic year	Undergraduate enrollments	Number of degrees
1950	201,927	52,732	1956	221,448	26,306
1951	161,592	41,893	1957	251,121	33,211
1952	145,997	30,286	1958	268,761	35,332
1953	156,080	24,164	1959	256,779	38,134
1954	171,725	22,236	1960	242,992	(1)
1955	193,692	22,589			

[1] Not available.

Source: U.S. Office of Education.

ENGINEERS IN THE U.S.S.R.

The engineering profession in the U.S.S.R., because of its special status, deserves particular attention. It has emerged as one of the largest single professional fields. The profession plays an important role in the civilian economy, in technological progress, and the military. As of January 1960, the U.S.S.R. had a total of nearly 1 million engineers—almost 30 percent of whom are women.

1969-70 1964-65 1959-60 1954-55 1949-50 1944-45 Sources: Office of Education and Soviet sources.

A very large proportion of these engineers have been produced through the Soviet educational system since the end of World War II, and the majority of them since 1950 as may be seen by the following tabulation.

Year and number of engineering graduates employed in the civilian labor force—U.S.S.R.

1941	290,000	1957	721,000
1951	392,000	1958	816,000
1954	481,000	1959	894,000
1955	530,000	1960	[1] 983,000

[1] Estimated.

These engineering graduates, who have received their diplomas from higher education institutions after a 5-year study program, are employed in many fields of specialization in the civilian economy. Table 5 below shows an estimated distribution of engineering graduates as of January 1960.

TABLE 5.—*Estimated distribution of engineering graduates by specialty, January 1960—U.S.S.R.*

Specialty groups	*Number*
Total	983,000
Geology and exploration of mineral deposits	42,000
Exploitation of mineral deposits	46,600
Power engineering	72,600
Metallurgy	50,000
Machine building and instrument construction	271,400
Electrical machine building and electrical instrument construction	49,800
Radio engineering and communications	47,900
Chemical technology engineering	79,300
Timber engineering and technology of wood processing, cellulose, and paper manufacturing	31,900
Technology of food products industry	32,200
Technology of consumers' goods industry	28,500
Construction	141,800
Geodesy and cartography	10,500
Hydrology and meteorology	8,000
Transportation	70,500

As shown in the growth of the engineering profession above, a very large proportion of the engineers have been graduated in the last decade. The following tabulation shows the annual number of graduates in the U.S.S.R. from 1950 to 1959.

Annual number of engineering graduates, U.S.S.R.

Year	*Number*	*Year*	*Number*
1950	36,000	1955	66,000
1951	44,000	1956	71,000
1952	47,000	1957	83,000
1953	46,000	1958	94,000
1954	56,000	1959	106,000

Engineering graduates have tripled in the past 10 years, and doubled in the last 5.

The U.S.S.R. has announced on several occasions its plans for future production of engineering graduates. Higher education is to graduate 1.9 times more engineers during the 7-year period of 1959–65 than in the previous 7-year period. This will mean an anticipated average annual output of about 125,000 engineers. The largest output of engineers during this 7-year plan will be in the fields of chemical technology, automation, computer technology, and electronics.

The quality of engineering training in the U.S.S.R. is high in the opinion of competent observers. The American Society for Engineering Education Exchange Mission to the Soviet Union in 1958 reported that diploma level training in engineering corresponds roughly in academic content to the U.S. bachelor's degree and in some respects approaches the master's degree level. Considerable

differences in the quality of engineering training programs were found to exist in the U.S.S.R. with a quality range "comparable to that found in the United States." At the graduate degree level, the mission found the kandidat degree approaching the level of the U.S. doctorate, and the doktor degree at a higher level of training.

The emphasis on engineering is further demonstrated in the data on advanced degree holders in the U.S.S.R. Of the total of about 105,000 holders of advanced degrees, more than one quarter are in engineering; at the doktor degree level alone, more than one-fifth are engineers. Furthermore, an examination of the fields of study of persons in graduate study—the Aspirantura—shows nearly two-fifths of all students are in engineering.

Despite the number and quality of engineers produced, there appear to be difficulties in meeting specific types of requirements. Chronic shortages and surpluses exist in some of the engineering specialties. It is difficult to determine whether such deficiencies are inherent in such a "statist" society where planning is concentrated in highly centralized state planning organs, or whether these are merely defects within the system of planning which will eventually be eliminated. In analyzing the efficiency of the Soviet planning system, a system which in many instances appears not to be able to measure correctly local supply and demand situations, some pertinent observations can be made. In such a planned society where considerations of supply and demand may be frustrated by human error in planning, some serious problems arise: (1) once the plans are put into effect, the impact of serious errors may be a cumulative effect; (2) unexpected future developments not anticipated by the planners may demand that the original planning be revised; (3) if a large scale important plan has to be revised in its early implementation stages, the result may be a "tinkering" with the educational system in order to make the required adjustment.

Comparative Engineering Curriculums

The standard Soviet engineering curriculums are normally 5–5½ years in length, and include about 4,400 to 5,100 hours of classroom and laboratory work. The U.S. curriculums are most generally 4 years (although there are an increasing number of 5-year courses) and will include about 3,000 to 3,200 hours of classroom and laboratory work; there is no "standard" curriculum for training engineers in this country. It is reported that U.S. engineering students will normally have more homework than is typically the case for Russian students.

An accompanying table compares typical engineering programs by general subject areas of study for electrical engineering in the United States and electronics in the U.S.S.R. This comparison shows hours of classroom instruction and laboratory work for a good 4-year college program for the United States. For the U.S.S.R., hours devoted to lectures, recitations, and laboratory work are shown.

Comparative curriculum [1] in electrical engineering for United States and U.S.S.R. by general subject area and instruction hours

General subject area	United States		U.S.S.R.	
	Hours	Percent	Hours	Percent
Total	3,080	100	4,364	100
Science and mathematics	680	22	1,044	24
General engineering	448	15	546	12
Specialized engineering	1,088	35	1,774	41
Academic, nonscience, and engineering	480	16	652	15
Other (physical education, military science, etc.)	384	12	348	8

[1] Represents standard U.S.S.R. 5-year course in electronics engineering and typical U.S. 4-year electrical engineering course (Carnegie Institute of Technology).

Sources: Final Report, ASEE Engineering Exchange Mission to the Soviet Union and Carnegie College of Engineering and Science Announcements for 1959–61.

Overall, the Soviet program totals 4,364 instruction hours, or about 42 percent more than the 3,080 in the U.S. program. U.S.S.R. hours in all subject areas are greater than for the comparable U.S. program, except for "Other" which includes physical education, military science, etc. In the specialized engineering subjects area, the U.S.S.R. curriculum at 1,774 hours exceeds the U.S. comparable course work by more than 60 percent. It is interesting to note that even in the non-science and engineering academic course work, the U.S.S.R. course contains a third more hours than the United States.

In terms of relative emphasis, the two countries devote a surprisingly close percentage of instruction time to the same subject areas. For example, the U.S. curriculum assigns 22 percent of instruction time to science and mathematics: The U.S.S.R. devotes 24 percent to these topics. Relatively large differences are shown in specialized engineering courses at 35 percent for the United States and 41 percent for U.S.S.R., and in "Other" where U.S. time accounts for 12 percent and U.S.S.R., 8 percent.

Recent visitors to engineering training institutions in the US.S.R. report and this cursory analysis tend to confirm the belief that there is a general comparability of training at the U.S.S.R. diploma level with the U.S. baccalaureate. While the Soviet system is sometimes criticized for extreme specialization in its engineering curriculum, it should be noted that such specialization is in addition to—rather than in lieu of—more general mathematics, science, and engineering course work. Furthermore, it is interesting that the Russian course requires foreign language instruction, which is an elective only in the typical U.S. engineering course.

The Training of Scientists and Research Scholars in the United States and U.S.S.R.

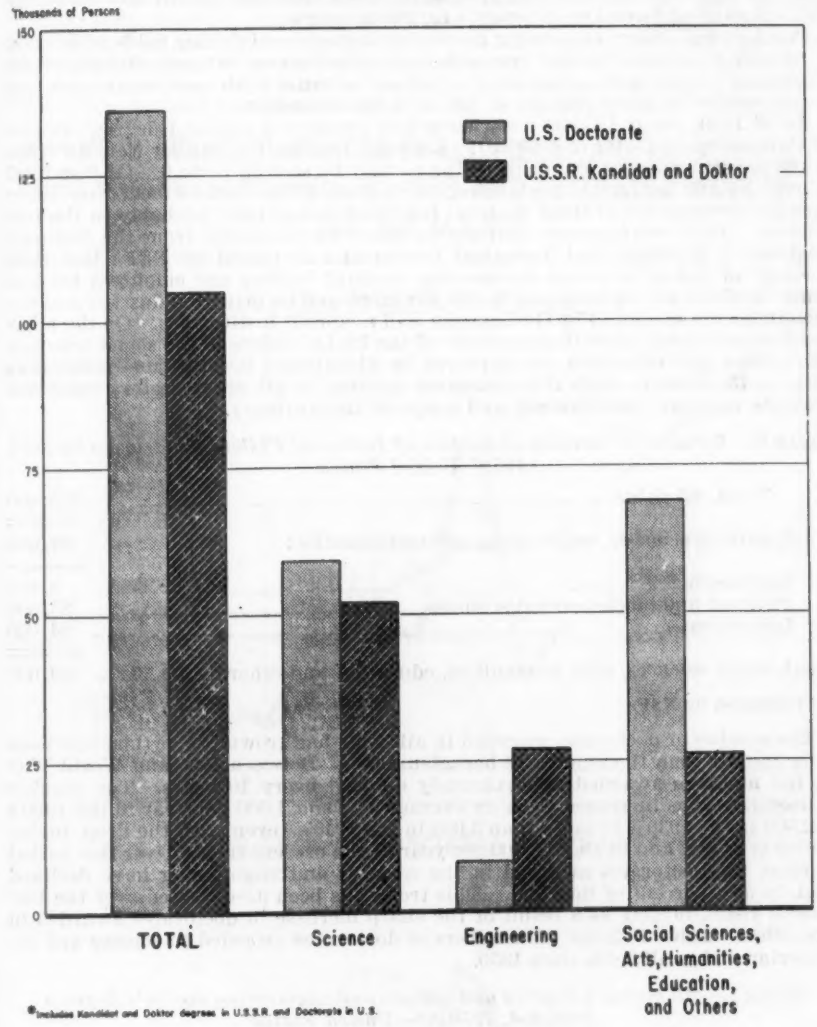
Scientists and research scholars are developed in both countries through an exacting course of training at institutions of higher education. The U.S. scientists will typically be trained at the graduate school of a university; in the U.S.S.R., similar training will be given at separate research institutes as well as in universities. Such training will normally commence at the baccalaureate level in the United States (after 4 years of college or university) and at the diploma level in the U.S.S.R. (after 4–6 years of university or institutes training).

The academic degrees, Doctor of Philosophy in the United States and Kandidat Nauk in the U.S.S.R., are usually considered to represent a roughly equivalent level of training, at least in the natural sciences and engineering. Both degrees represent successful completion of an intensive academic course and independent research. An additional degree, the Doktor Nauk, may be earned by eminent Soviet scientists largely as a recognition of important scientific contributions.

At the present time, the United States has more than 135,000 persons who have earned a doctorate. In the U.S.S.R., there are nearly 105,000 persons with an advanced degree—more than 10,000 of them hold a "doktor" degree. The distribution of advanced degree holders is very different in the two countries. About half of the U.S. doctorates are degrees in the natural sciences and engineering while in the U.S.S.R. more than three-quarters are in science and engineering (engineering alone accounts for more than one-third). Furthermore, even in the sciences there is a difference in emphasis; the United States has a larger proportion in the physical and mathematical sciences; the U.S.S.R. a larger proportion in life sciences (particularly agriculture). Another difference between the two countries is in the area of medicine and related fields. These fields in the U.S.S.R. comprise about 17 percent of all advanced-degree holders. In the United States most medical personnel receive a terminal M.D. (doctor of medicine) or similar degree (even though some undergo additional training) and very few obtain a Ph. D.

At the present time, the United States is awarding about 9,000 doctorates annually with about half of them in the natural sciences and engineering. On the other hand, annual production of Kandidat degrees in the U.S.S.R. is now about 5,000 with about three-quarters in the sciences or engineering. This latter rate has fluctuated widely, however; in 1954 and 1955 it was about 12,000. Over the next decade it is likely that U.S. doctorate production will double; in the U.S.S.R. present indications are that the rate of increase may be smaller.

ESTIMATED NUMBER OF ADVANCED DEGREE* HOLDERS, 1959
U.S. and U.S.S.R.



*Includes Kandidat and Doktor degrees in U.S.S.R. and Doctorate in U.S.

Source: NSF estimates and Soviet sources.

THE DOCTORATE LEVEL OF TRAINING IN THE UNITED STATES

Graduate training in the United States covers a broad educational range reaching from the baccalaureate level to postdoctoral study and research. It is usually distinguished from professional schools which train to an increasing extent after completion of the 4-year baccalaureate course, personnel for law, the clergy, medicine, and other professions. The typical student will enroll for graduate training in the graduate school of arts and sciences at a university after 4 years of undergraduate college or university study culminating in the bachelor's degree. The Doctor of Philosophy degree represents the successful completion of an exacting course of study and research equivalent to 4- or 5-year's full-time work. (Since study is frequently on a part-time basis, or is interrupted by intervening employment, the average period between the award of the bachelor and doctoral degrees is now about 8 years.)

The master's degree is often awarded after 1 or 2 years of graduate study. At one time considered to be a major step in meeting course requirements for the doctorate, the master's degree is assuming less importance in many fields so that the graduate student will frequently work directly toward the doctorate without meeting formal requirements for the master's.

Postdoctoral study is assuming increasing importance in many fields of science. It usually represents further research in specified areas, but may also represent "refresher" training to acquaint the mature scientist with new techniques and developments in fields related to his own specialization.

As of 1959, about 136,000 Americans held an earned doctoral degree (Doctor of Philosophy or doctor of science). Roughly, half of this number were awarded in the natural sciences and engineering as may be seen in table 6. Of this total of over 136,000 holders of doctorates, about three-fifths were earned after 1950; thus the average age of these doctoral holders is fairly low—probably in the late thirties. Their employment distribution has been estimated from the National Register of Scientific and Technical Personnel maintained by NSF: less than one-half of the science and engineering doctoral holders are employed by academic institutions; at least one-fourth are employed by private industry; and the remainder are employed by Government and nonprofit institutions. On the other hand, considerably more than one-half of the Ph.D. holders in the social sciences, humanities, and education are employed by educational institutions—perhaps as high as 75 percent—with the remaining quarter in all other sectors combined (private industry, Government, and nonprofit institutions).

TABLE 6.—*Estimated* [1] *number of holders of Doctor of Philosophy degrees by field, 1959—United States*

Total, all fields	136,000
Total, natural sciences, engineering and mathematics:	67,000
Engineering	8,000
Physical and mathematical sciences	35,000
Life sciences	24,000
Total, social sciences, arts, humanities, education and other	69,000

[1] Estimated by NSF.

The number of doctorates awarded in all fields has grown proportionately even more rapidly than the number of baccalaureates. Between 1900 and World War II, the numbers awarded approximately doubled every 10 years. The number of doctorates has increased from an average of about 1,000 per year in the 1920's to 2,500 in the 1930's, to more than 3,000 in the 1940's (even with the drop during World War II), and to about 9,000 per year at the present time. Over this period of time, the doctorates awarded in the sciences and engineering have declined slightly as a percent of the total. This trend has been accentuated over the last several years, largely as a result of the sharp increase in doctorates awarded in education. Table 7 shows the numbers of doctorates awarded in science and engineering and in all fields since 1950.

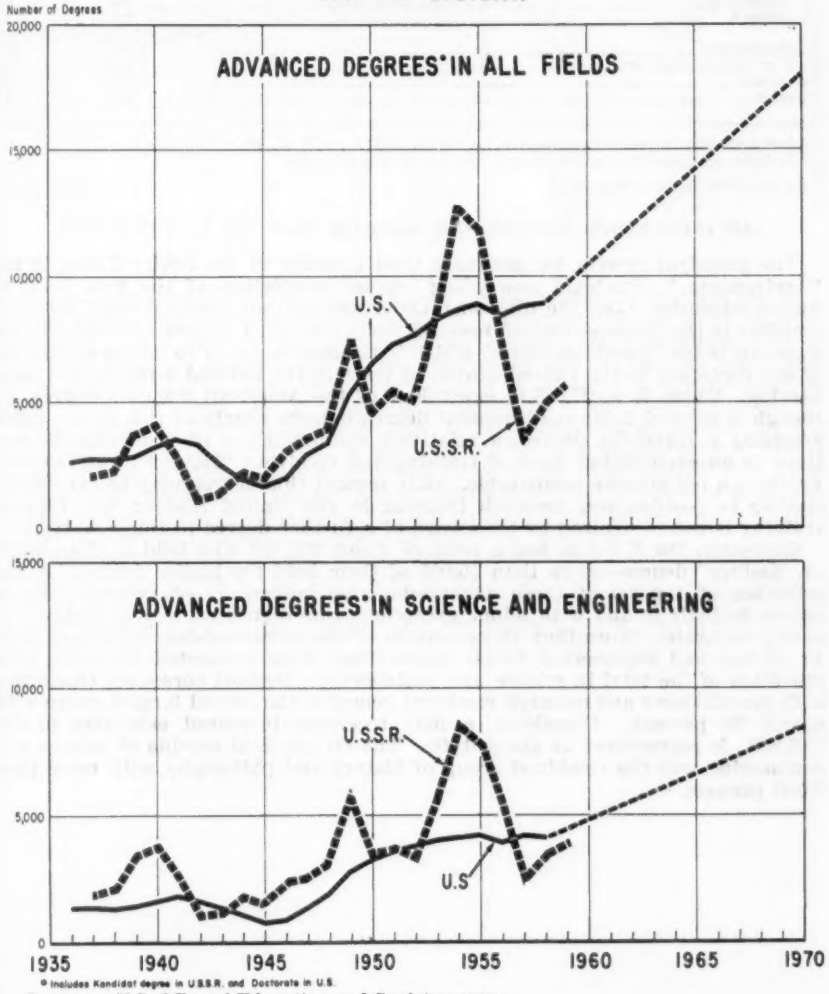
TABLE 7.—*All doctor's degrees and science and engineering doctor's degrees awarded, 1950–58—United States*

Academic year	Number of doctor's degrees awarded		Percent science and engineering of total doctor's degrees	Academic year	Number of doctor's degrees awarded		Percent science and engineering of total doctor's degrees
	All degrees	Sciences and engineering			All degrees	Sciences and engineering	
1950	6,633	3,593	54.2	1955	8,840	5,036	57.0
1951	7,338	4,212	57.4	1956	8,903	4,787	53.8
1952	7,683	4,408	57.4	1957	8,756	4,764	54.4
1953	8,309	4,724	56.9	1958	8,942	4,840	54.1
1954	8,996	5,053	56.2				

Source: U.S. Office of Education.

The number of doctoral degrees awarded is expected to grow substantially in future years, provided adequate resources can be obtained for the required expansion of the facilities and staff of the universities awarding such degrees. Best available projections indicate that doctorates awarded may well increase to more than 10,000 in the early 1960's and to more than 18,000 by 1970. On the assumption that doctorates in science and engineering will continue at the same relative proportion of all fields as currently, they will number about 8,500 by 1970 as compared with 4,840 in 1958. As may be seen by table 8, more doctorates are granted in education than in any other single field. The physical

ADVANCED DEGREES* AWARDED IN ALL FIELDS AND IN SCIENCE AND ENGINEERING, 1936 TO 1958 AND ESTIMATED TO 1970, U.S. and U.S.S.R.



* Includes Kandidat degree in U.S.S.R. and Doctorate in U.S.

Sources: U S. Office of Education and Soviet sources.

sciences together represent a larger number, however, with the largest single discipline being chemistry with about 1,000 degrees awarded annually. More than 450 such degrees are awarded in physics. Other fields in which substantial numbers of doctorates are awarded include engineering with about 650 degrees, psychology with 570, English and journalism with 355, and mathematics with nearly 250.

TABLE 8.—*Number of doctor's degrees awarded by broad field, academic year 1957–58—United States*

Field	Number of doctor's degrees	Percent
Total, all fields	8,942	100.0
Natural sciences	4,840	54.1
Agricultural sciences (including forestry)	340	3.8
Biological sciences (including health specialties [1])	1,272	14.2
Engineering	647	7.2
Mathematics	247	2.8
Physical sciences	1,655	18.5
Psychology	572	6.4
Other [2]	107	1.2
Social sciences	1,055	11.8
Fine arts and humanities	1,170	13.1
Education	1,638	18.3
All other	239	2.7

[1] But excluding 1st professional degrees, i.e., M.D., D.D.S., D.V.M., etc.
[2] Includes anthropology, geography and "science, general program."

Source: U.S. Office of Education.

ADVANCED-DEGREE HOLDERS AND GRADUATE TRAINING IN THE U.S.S.R.

The principal system for graduate level training in the Soviet Union is the "Aspirantura." Students proceeding beyond completion of the first level of higher education (i.e., the diploma) undertake further academic and research training in the universities and research institutions. The first academic degree awarded is the "Kandidat Nauk" which is thought by many to be the equivalent of the doctorate in the United States, at least in the natural sciences and engineering. There is no U.S.S.R. equivalent of the American master's degree, although in several fields the Kandidat degree is more nearly at this level. After receiving a Kandidat degree, a relatively small number of professionals continue to an even higher level of training and receive a "Doktor Nauk" degree. (Although not strictly comparable, study toward this degree may be considered similar to postdoctoral research training in the United States; this type of training is not recognized by the award of a further degree in this country.)

Currently, the U.S.S.R. has a total of about 105,000 who hold a "Kandidat" or "Doktor" degree—more than 10,000 of them hold the higher degree. A distribution of 100,000 of these advanced-degree holders as of October 1958 is shown in table 9, and with minor exceptions this distribution is probably currently accurate. More than three-fourths of the advanced-degree holders were in science and engineering fields—engineering alone accounted for more than one-third of the total in science and engineering. Medical personnel (including both practitioners and research workers) comprise the second largest group with nearly 25 percent. Chemistry, a field receiving increased emphasis in the U.S.S.R., is represented by about 6,000. The largest field outside of science and engineering was the combined group of history and philosophy with more than 8,500 persons.

TABLE 9.—*Number of advanced-degree holders by field, October 1958—U.S.S.R.*

Field	Number of advanced degree holders		
	Total	Kandidat Nauk	Doktor Nauk
Total, all fields	100,242	89,960	10,282
Scientific, medical, and engineering	75,679	66,616	9,063
Agriculture and veterinarian	7,890	7,090	800
Biology	7,332	6,281	1,051
Chemistry	5,847	5,199	648
Engineering	25,932	23,869	2,063
Geography	1,600	1,440	160
Geology and mineralogy	3,184	2,654	530
Medicine and pharmaceutics	17,119	14,222	2,897
Physical-mathematical	6,775	5,861	914
Other fields of knowledge	24,563	23,344	1,219
Architecture	445	404	41
Art	746	673	73
Economics	4,718	4,475	243
History and philosophy	8,670	8,311	359
Law	1,332	1,230	102
Pedagogy	2,272	2,192	80
Philology	5,235	4,936	299
Others	1,145	1,123	22

Source: U.S.S.R. official publications.

A survey of roughly half of the advanced degree holders shows that about 50 percent of the Kandidat degree recipients in the period 1946–53 were between 30 and 40 years of age upon receiving this degree. Approximately half of those obtaining the Doktor degree were between 40 and 50 years of age. This would indicate that the advanced degree holders in the U.S.S.R. are a somewhat older group in general than those holding doctorates in the United States.

Information on the current activities of advanced degree holders in the U.S.S.R. indicates that over half of them are employed by institutions of higher education and another third are employed by scientific research institutes. Another partial coverage survey of Doktor degree holders shows that a high proportion of them have considerable teaching experience—44 percent had between 10 and 20 years and another 20 percent have more than 20 years.

A large percentage of the advanced degrees in the U.S.S.R. have been awarded in the last two decades. At the Kandidat level practically all of the degrees were awarded in the period 1937–55. Table 10 shows the fields in which these degrees were awarded—the largest fields being engineering and medicine and pharmaceutics.

TABLE 10.—*Number of Kandidat Nauk degrees awarded, 1937–55—U.S.S.R.*

Field	Number of degrees awarded				Total
	1937–40	1941–45	1946–50	1951–55	
Total, all fields	12,553	9,756	22,744	43,620	88,673
Scientific, medical, and engineering	11,179	8,202	17,410	29,489	66,280
Agriculture and veterinarian	908	712	1,946	3,145	6,711
Biology	780	686	1,536	2,948	5,950
Chemistry	499	452	1,188	1,714	3,853
Engineering	3,786	3,150	6,971	11,996	25,903
Georgraphy	247	184	389	587	1,407
Geology and mineralogy	216	295	807	1,028	2,346
Medicine and pharmaceutics	3,968	2,223	3,566	6,109	15,866
Physical-mathematical	775	500	1,007	1,962	4,244
Other fields of knowledge	1,374	1,554	5,334	14,131	22,393
Architecture	32	34	108	233	407
Art	55	93	202	372	722
Economics	171	276	925	2,347	3,719
History and philosophy	289	394	2,158	5,224	8,065
Law	100	64	243	861	1,268
Pedagogy	242	222	618	1,643	2,725
Philology	311	385	1,021	2,834	4,551
Others	174	86	59	617	936

Source: U.S.S.R. official publications.

The more than 10,000 Dokter degrees (a further advanced degree without a U.S. counterpart) awarded during this same period are shown by field of study, table 11. Here again engineering and medicine and pharmaceutics are the largest fields. From these tables it can be seen that the period 1951–55 was a particularly fruitful period for the awarding of advanced degrees at both levels. More than two-fifths of the candidate degrees awarded in science and engineering fields in the 1937–55 period were in the 1951–55 span.

TABLE 11.—*Number of Dokter Nauk degrees awarded, 1937–55—U.S.S.R.*

Field	Number of degrees awarded				Total
	1937–40	1941–45	1946–50	1951–55	
Total, all fields	2,708	2,380	2,705	2,886	10,674
Scientific, medical, and engineering	2,454	2,078	2,325	2,533	9,390
Agriculture and veterinarian	175	181	207	294	857
Biology	273	245	254	318	1,090
Chemistry	109	151	152	184	596
Engineering	514	539	623	684	2,360
Geography	21	26	44	42	133
Geology and mineralogy	95	107	174	150	526
Medicine and pharmaceutics	1,112	698	697	681	3,188
Physical-mathematical	155	131	174	180	640
Other fields of knowledge	249	302	380	353	1,284
Architecture	7	11	19	6	43
Art	6	27	31	13	77
Economics	49	44	52	79	224
History and philosophy	81	98	111	104	394
Law	26	26	44	27	123
Pedagogy	36	26	24	30	116
Philology	43	61	90	87	281
Others	1	9	9	7	26

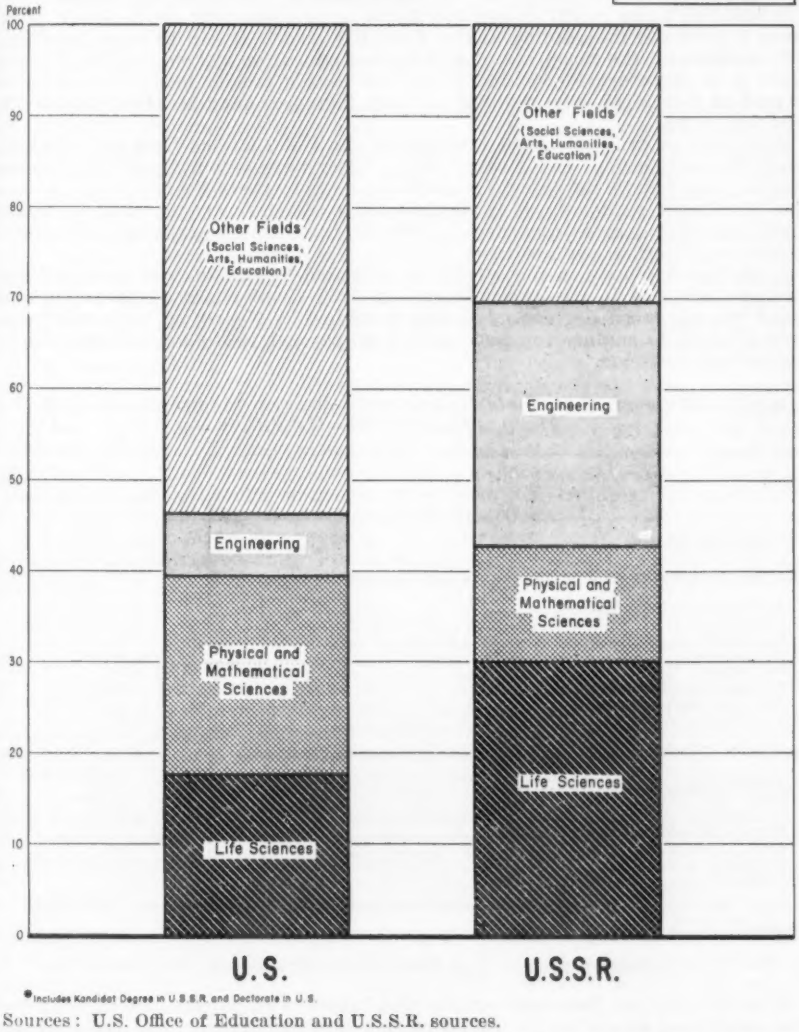
Source: U.S.S.R. official publications.

The sharp rise in the number of Kandidat degrees awarded, particularly during the period 1951–56, is attributable to the Government's systematic program for stimulating the awards of Kandidat degrees to academic and research personnel nearly eligible for such degrees. This was done through a selective

draft system whereby they were officially encouraged to accelerate their Kandidat dissertational work while at the same time holding their jobs and pay status in their regular places of employment.

PERCENT DISTRIBUTION OF ADVANCED DEGREES* AWARDED IN SELECTED FIELDS, 1955-1958, U.S. and U.S.S.R.

DEGREES AWARDED 1955-58
U.S..... 27,000 Doctorates
U.S.S.R. 28,000 Kandidat Degrees



*Includes Kandidat Degree in U.S.S.R. and Doctorate in U.S.

Sources: U.S. Office of Education and U.S.S.R. sources.

The administrative machinery for implementing this program began with the recommendation of the Council of Ministers that the Ministry of Higher Education work out a new postgraduate training program for the Council of Ministers approval. Thus, on November 17, 1950 the Council of Ministers approved the "Regulation on the Aspirantura in the Higher Educational Institutions and in the Scientific Research Institutes." This regulation was instrumental in accelerating the completion of formal requirements by large numbers of aspirants to the Kandidat Nauk degree.

After a large number of the most qualified aspirants had obtained the degree, the number of awards began to decline. The system for accelerating the award of Kandidat degrees did result in an extremely sharp increase of such awards, particularly during the 1951–56 period, but it also resulted in the awarding of degrees to some less-qualified people. As recently as February 1960, the central committee of the party and the Council of Ministers indicated that "there were serious deficiencies in the training and attestation of academic and scientific research personnel * * * the Higher Attestation Commission under the Ministry of Higher and Specialized Secondary Education has not provided the needed control as regards the quality of the dissertations for the Kandidat degree."

In spite of these recent difficulties, there is no doubt that the U.S.S.R. places great importance on training at the Kandidat level. It can be expected that it will marshal all the resources of a mobilized education system to solve its problems; it is therefore reasonable to assume that a steady increase in numbers trained at this level—and possibly a sharp increase—may be expected over the next few years.

Emphasis on graduate level training in the U.S.S.R. has been placed on the scientific, engineering, and medical fields. About three-fourths of all advanced degrees awarded in the last 20 years have been in these fields and the proportion of current recipients of these degrees is about the same. The estimated 5,000 Kandidat degrees awarded in 1959 continue this pattern of emphasis on science, engineering, and medicine.

A similar emphasis on these fields is indicated by the fields of study of those currently enrolled in the Aspirantura. In 1959 about 23,000 students were enrolled for advanced degrees as shown in table 12. Nearly 40 percent of them were enrolled in engineering and another 40 percent in the various branches of science and medicine.

TABLE 12.—*Number of students for advanced degrees (Aspirantura) by field of study, January 1959—U.S.S.R.*

	Number of students	Percent distribution
Total, all fields	23,084	100.0
Scientific, medicine and engineering	18,330	79.4
Agriculture and veterinarian	1,633	7.1
Biology	1,053	4.6
Chemistry	1,186	5.1
Engineering	8,890	38.5
Geography	217	.9
Geology and mineralogy	804	3.5
Medicine and pharmaceutics	1,843	7.9
Physical-mathematical	2,704	11.7
Other fields of knowledge	4,754	20.6
Architecture	84	.4
Art	358	1.6
Economics	1,584	6.9
History and philosophy	1,013	4.4
Law	194	.8
Pedagogy	440	1.9
Philology	1,081	4.7

Source: U.S.S.R. official publications.

SUBPROFESSIONAL AND SUPPORTING TECHNICAL STAFF

In both countries there are substantial numbers employed in technical positions requiring specialized training of a somewhat shorter and more applied character than that required to develop engineers and scientists. These occupations include the scientific and engineering aids, draftsmen, electronics maintenance and repairmen, laboratory assistants, etc. They are usually considered to occupy a place in the skills hierarchy between the professional and the skilled worker.

In the United States, there were an estimated 850,000 technicians working in the engineering and physical sciences fields in 1958. Approximately 600,000 were employed in private industry, principally in manufacturing. These workers were trained through a variety of institutions including technical institutes,

vocational and trade schools at the secondary level, industry, and the Armed Forces training schools.

Training for these occupations in the U.S.S.R is a part of the formal educational system. About a million and a quarter (over 30 percent) of the population with specialized secondary school training in 1958 were in the occupational group known as technicians. This group includes some persons who have had only 2 years of schooling beyond the 7-year schools; others have had as much as 4 years beyond the 10-year school. Thus, the graduates of the specialized secondary system range from semiskilled workers in mechanical trades to highly skilled engineering and scientific technicians. In general, this training is designed to meet the needs of Soviet industry for technically trained persons.

TECHNICIANS IN THE UNITED STATES

Professional engineers and scientists are frequently assisted by workers in a variety of occupations covering a broad group of skills and loosely termed technicians. These occupations typically include scientific and engineering aids, laboratory assistants, electronic technicians, draftsmen, etc. They are found performing functions in research, development, production, maintenance, product service, and repair. Technician occupations are generally considered to fit between the professional level of training and responsibility and the skilled level. Their duties range from simple routine tasks to work of a highly technical nature which overlaps the work of the engineer and scientist. Technicians often utilize complex electronic or mechanical instruments, experimental laboratory apparatus, drafting instruments, tools, and machinery. Sometimes they are employed in a supervisory capacity, and require both technical knowledge and management skills.

American technicians receive their training through a great variety of methods. Some of the more conventional training systems are those of the technical institutes, the junior and community colleges, and the vocational and trade secondary schools. Large numbers, however, are also trained in the Armed Forces service schools, correspondence schools, and industrial classes, or acquire technician training through on-the-job experience and training. In past years, many were trained in Europe and migrated to this country.

Technician training is in a stage of rapid development in the United States. It has been attaining recognition as a form of higher education; that is, it represents training at a level beyond the secondary school and typically requires a prerequisite high school education.

Somewhat more than 13,000 graduated in engineering-related curriculums of at least 1 year (but less than 4 years in length) from technical institutes, junior colleges, and similar institutions in 1957, the last year for which data are available. An estimated 76,000 were enrolled in such courses of study at those institutions. In view of the rapidly growing nature of such training, it is probable that not less than fifteen thousand to twenty thousand are currently completing such training each year, and enrollments are estimated at 100,000.

Technicians represent a key group in any program to expand the potential in science and engineering. On the one hand, they serve to extend the professional's services by assisting in performing some part of his tasks; on the other, they interpret and direct other segments of the work force to utilize the applications of science and engineering effectively.

TECHNICIANS WITH SPECIALIZED SECONDARY EDUCATION IN THE U.S.S.R.

The specialized secondary schools of the U.S.S.R. provide training of 2 to 4 years in duration for the graduates of the 7- and 10-year schools (under the reform to become the 8- and 11-year schools). They provide training not only in such fields as agriculture, economics, teaching, and technical subjects, but also in law, medicine, and pharmacy. They include levels of training ranging from that of the high school to that of the technical institute in the United States.

Soviet sources report a total of about 4 million with specialized secondary education in 1958. Of this number about 1,250,000, or a third, are graduates in technical fields. These fields comprise several types of workers including the semiskilled in mechanical trades and high-level engineering and scientific technicians. The length of training given these graduates varies from 2 years beyond the 7-year school to as much as 4 years beyond the 10-year school. This group of technically trained workers has increased from a total of about 320,000 in 1941; in other words, this body of workers has quadrupled in a 20-year period, a considerable portion of which was disrupted by war.

Professionals in Academic and Research Activities

A measure of the relative scientific research and education activities of the United States and the U.S.S.R. is the number of professional personnel engaged in research and training at the higher education level.

In the U.S.S.R. a special group of academic and research personnel includes the most highly qualified research workers and the faculty of institutions of higher education. This group of "Nauchnye Rabotniki" (literally, scientific workers) includes the advanced-degree holders, the faculties of the institutions of higher education, responsible research investigators, etc. This group has approximately doubled each 10 years since 1940, and numbered 310,000 early in 1960. Nearly three-quarters of them are engaged in work in the physical sciences and engineering. It is this group of highly qualified personnel (supplemented by some 200,000 other staff in planning, design, development, etc.) which the U.S.S.R. has mobilized to achieve the startling technological progress and scientific advances of recent years.

There is no comparable group separately identified as such in the United States. If, however, the faculty of institutions of higher education is added to the number of professionals engaged in scientific research and development in industry, government, etc., the total of 605,000 is reached. To this may properly be added another 10,000 advanced-degree holders not engaged in research or higher education for a total of 615,000, which provides an approximate comparison.

While the differences between the two countries are apparently large in this rough comparison, conclusions should be reached cautiously in view of the nature of the data. The apparent difference shrinks considerably when attention is paid to the indicated comparable data on science and engineering. An estimated 223,000 of this group are engaged in such activities in the U.S.S.R. with a comparable U.S. figure of about 400,000. The difference in numbers comes close to disappearing if any substantial part of the 200,000 personnel engaged in design, development, etc., are added to the U.S.S.R. total.

Higher Education Faculty and Research and Development Professional Personnel in the United States

Many of this Nation's most able professional personnel, particularly those in scientific and technical fields, either are employed as faculty members in colleges and universities or are engaged in research and development activities in industry, government, and other research organizations. Not all of our most qualified personnel are engaged in these activities nor are all such personnel more qualified than those engaged in other functions. However, the delineation of this group of personnel helps to quantify a good portion of our top level professional personnel. In the Soviet Union this group of persons is characterized as "Academic and Research Personnel." The tabulation below is an attempt to identify for the United States a group somewhat similar to the U.S.S.R. group. However, it should be emphasized that comparability between these two groups is a most general one at best.

More than 600,000 persons are included in the U.S. group described as higher education faculty and research-development professional personnel. The following tabulation shows a distribution of these persons:

Faculty and research-development professional personnel in colleges and universities	280,000
Research-development professional personnel other than in colleges and universities	325,000
Other holders of doctorates	10,000
Total	615,000

By far the largest proportion of this group are scientists and engineers, including nearly all of the research-development professional personnel outside of colleges and universities, at least a quarter of the higher education faculty, and probably half of the holders of doctorates outside of the other two sectors.

Academic and Research Personnel (Nauchnye Rabotniki) in U.S.S.R.

At the core of the Soviet scientific and higher education effort is the academic and research personnel, or "Nauchnye Rabotniki." This relatively small group

is comprised of the professionals who man the institutions of higher education in all fields, who carry on scientific research, and who comprise the membership of the scientific and learned academies. This group is responsible for the recent spectacular successes in Soviet science and technology. It includes the fields narrowly considered to be science in the United States but also fields of the social sciences and humanities, such as history and philosophy, economics, law, pedagogy, and philology.

This elite group numbered about 284,000 in 1959, distributed as follows:

In scientific institutions	135,700
In higher education institutions	141,000
In enterprises, establishments and administrative staffs	7,300
Total	284,000

It has continued to grow and is estimated at 310,000 in early 1960.

This group, for which no similar body can be identified in the United States, includes all advanced degree holders in the U.S.S.R. It has grown from less than 100,000 in 1940 at a rate which approximately doubled the total by 1950 and again by 1960. About 50 percent of its membership are engaged in the physical sciences and engineering; another 22 percent in the biological sciences and agriculture; and 26 percent in the arts, humanities, and social sciences.

For some purposes, there should be added to this group about 200,000 professionals who are employed in planning, design, development, geological survey, etc., organizations. This secondary group serves the more elite group and acts to supplement its works.

WOMEN EMPLOYED IN SCIENCE

Mr. OSTERTAG. Dr. Revelle, you mentioned a few moments ago something about the number of women scientists engaged in this work, with the implication that women are excluded or not permitted or are not involved in scientific work in our country. Did you mean to say that we have no women scientists?

Dr. REVELLE. I do not think we have anywhere near as many as we could have. This is not because of any formal exclusion of women, but it is because of the mores of this country.

Mr. OSTERTAG. How do you account for that?

Dr. REVELLE. There is a very good article in this week's Newsweek touching on this point of American women and their role in our society. It is basically the tremendous emphasis that we have developed lately on togetherness of the family, and so forth.

Mr. THOMAS. I gather when you talk with the Russians the first thing they start bragging about is equal work draws equal pay and there is no difference between the men and the women as far as industry is concerned. They are defending all its women doing that street sweeping at 4 o'clock in the morning in the streets of their cities, but they make no distinction between them. Their theme is "Equal Work, Equal Pay, and Equal Opportunity." They follow up on it and they go to the high schools and universities, and so forth. If you go in their industrial plants you will find a lot of top jobs held by women.

Dr. WATERMAN. I can add something to this matter of the women in Russia working in scientific and related fields. If I remember correctly, the majority of physicians in Russia are women. I believe, also, that about 30 percent of engineers in Russia are women, whereas, I think it is less than 1 percent in this country. Dr. Kelly's staff has made a study on American women in science and engineering, and I think he has some information on Russia also.

Dr. KELLY. Yes, sir. We have some information on the employment of women in both countries. Dr. Waterman is correct on the employment of women as physicians and engineers. The situation, roughly, is that women make up an important part of the work force in both countries, but that the emphasis is different with respect to the kinds of work they are engaged in. Altogether, there are more than 20 million employed women in the United States. About 2 million of these are classified in the professional group. About 40 percent of these are teachers and another 25 percent are nurses. According to the U.S. Census Bureau, about 12 percent of our scientists, about 6 percent of our physicians and surgeons, and about 1 percent of our engineers are women. On the other hand, the great difference is illustrated in estimates that about three-quarters of the professional-level workers in medicine in Russia are women, as are about 30 percent of the engineers.

With respect to college graduates and advanced degrees, about one-third of our baccalaureate degrees are awarded to women as well as well as about one-tenth of the doctorates. The difference between the two countries, again, is one of areas of specialization. Both countries are training large numbers of women as teachers. Beyond that, the U.S.S.R. is training women predominantly in the health professions and engineering, while greater numbers of ours are in the social sciences and the humanities.

Mr. THOMAS. Could you provide a more formal statement on this subject for the record, Dr. Kelly?

Dr. KELLY. Yes, sir.

(The information requested follows:)

PROFESSIONALLY TRAINED AND EMPLOYED WOMEN WORKERS

Women represent a substantial proportion of the work force in both the United States and the U.S.S.R., particularly in the professional occupations. While the measures which must be used for comparisons are deficient in some respects, they are sufficiently alike that major points of similarity and dissimilarity are clear.

About 21 million women are employed in the United States in all occupations. Of this number about 2.7 million are working at "professional, technical, and kindred" jobs. This number represents about 37 percent of all such workers. Of the 2.8 million professional workers (i.e. those who have completed higher education) in the civilian economy of the U.S.S.R., about 1.5 million or 52 percent are women.

An inspection of the fields in which women are professionally employed in the two countries shows significant differences. About two-thirds of the women working at this level in the United States are either teachers or nurses, and they account for 75 and 98 percent of the respective totals in these two occupations. In the U.S.S.R., education and medicine also account for about two-thirds of the professionally employed women and they comprise 65 and 75 percent of the respective occupational totals. However, in the U.S.S.R., about 16 percent of the professionally employed women are in engineering, and they represent nearly a third of the total in that occupation.

Currently about one-third of the baccalaureates are awarded to women in the United States, and about one-tenth of the doctorates. In the U.S.S.R., about half of those enrolled in higher education are women, and women hold about 20 percent of the advanced degrees. While women in both countries are trained in the greatest numbers in education, very large numbers are trained in the U.S.S.R. in the health professions and in engineering. In the United States, large numbers are trained in the social sciences and humanities.

UTILIZATION OF WOMEN WORKERS IN THE UNITED STATES

Women form an important segment of the labor force in the United States with more than 21 million employed in 1959—about one-third of all employed persons. Nearly two-fifths of all professional, technical and kindred workers are women, and this group of women workers forms nearly 13 percent of all employed women. While teaching and nursing have traditionally been the largest occupations of women professional workers, there has been considerable diversification among the professions entered by them. In 1950, of the 2 million women classified in the professional group, more than two-fifths were teachers and nearly another quarter were nurses as shown below. These proportions have not greatly changed.

Occupations of women in 1950—United States	Number employed (thousands)	Percent of all workers in occupation
Total	1,940	39
Teachers, not elsewhere classified	835	75
Nurses, professional and student professional	463	98
Dietitians and nutritionists	21	94
Librarians	49	89
Authors, editors, and reporters	35	35
College presidents, professors, instructors, not elsewhere classified	29	23
Accountants and auditors	56	15
Medical and dental technicians and therapists and healers	55	55
Other technicians	21	21
Natural scientists, including chemists	13	12
Architects	1	4
Dentists	2	3
Draftsmen	8	7
Engineers	6	1
Pharmacists	7	8
Physicians and surgeons	12	6
Other	327	25

Source: U.S. Bureau of the Census.

There has been a steady upward trend in the educational level of women workers. In 1958, one-third of all bachelor's degrees were awarded to women, almost one-tenth of the doctorates. At the bachelor's degree level by far the largest numbers of degrees for women were in education, the next largest were in social sciences, followed by English, journalism, foreign language and literature. The proportions were roughly the same at the master's and doctoral level. About 7 percent of the baccalaurcates awarded to women were in the health professions, and less than 6 percent were in natural sciences. Degrees in engineering were negligible.

As may be seen from the information on numbers being trained and the number employed, women play a relatively minor role in scientific and technical employment at the professional level. Probably not more than 10 percent of scientists (strictly defined) in all fields are women, less than 1 percent of the engineers are women, and over 5 percent of professional medical workers, excluding nursing, are women. This is not to say that women play an insignificant role in these fields. There are outstanding women scientists and engineers, and in some fields of sicence they are a substantial proportion of the total.

Psychology, chemistry, and the biological sciences are the largest fields of employment of women scientists. Furthermore, women constitute more than 20 percent of the teaching faculty in institutions of higher education. The traditional fields for women (health professions, education, home economics, and library sciences) have the laregst proportions of women faculty members.

The relatively small role that women play in scientific and technical employment is not a matter of ability but rater of personal choice and motivation. Traditionally, fewer women than men attend college and still fewer go on to graduate training. Many of those receiving training in science and engineering as well as all other fields, either do not enter the labor force or leave it because of other obligations—marriage and children. There is also a strong tendency for those women who do make science their careers to concentrate in a relatively small number of scientific fields.

WOMEN PROFESSIONALS IN THE U.S.S.R.

The U.S.S.R. has been singularly successful in supplementing its civilian work force by the use of women workers at all levels. Heavy male losses during World War II and the expanding labor requirements of a rapidly growing industrial economy together have placed a severe strain on U.S.S.R. manpower resources. The natural desire to acquire additional income to improve the family living standard above the Spartan levels permitted by the Soviet economy has been a large factor in encouraging women to participate in the labor force. The state has further encouraged and made such participation possible by a liberal investment in maternity and child care benefits.

Women employed in the civilian economy and trained at a level equivalent to U.S. college and university training numbered nearly 1.5 millions in 1958, and actually represented about 52 percent of the total trained at this level. The tabulation below shows numbers of women employed and percentage of women to totals by fields of study.

Fields	Number of women with higher education and employed	Percentage women to total employed
Total	1,467,100	52
Agriculture	73,400	38
Economics	89,800	57
Education [1]	744,200	65
Engineering	236,700	29
Law	18,500	32
Medicine	259,500	75
Other	45,000	50

[1] Includes sciences.

Source: U.S.S.R. official publications.

It will be noted that women professionals particularly represent a large percentage of the total in medicine (75 percent) and education (65 percent). Even in engineering, a field traditionally reserved for males in most countries, 29 percent are women.

At the secondary school level of training, the pattern is repeated. About 65 percent of the civilian economy workers with specialized secondary school training are women. Again medicine and education are the fields particularly dominated by women (91 and 80 percent). However, 74 percent of the workers trained in economics at this level are women, as are 40 percent of those trained in "technical" subjects.

The highly trained academic and research personnel category is composed of about 36 percent women, and about the same percentage holds true for the faculties of higher education institutions. An estimated 20 percent of the advanced degree holders in all fields are women.

In the foreseeable future, the proportions of women in the U.S.S.R. professional work force will probably not shift greatly. About half of the students currently enrolled in higher education are women, and they may be expected to continue to dominate the fields of education and medicine. The proportion enrolled in engineering is about the same as current employment in this field.

QUALITY OF TRAINING IN SCIENCE

Mr. THOMAS. Now we want to hear from the distinguished Board members.

Dr. WATERMAN. One point that Dr. Stratton commented on is the quality of our education. I think everyone is pretty well aware of this and we have spoken about it many times. We do a very good job, and our major universities certainly give the very best possible training. Our weakness is in the large number of colleges and universities where it is difficult to get good science teachers and good

science research people. We could broaden our potential very greatly if we strengthened these institutions. Another place where we need additional strength is in the teaching of science in the lower grades and the secondary schools. That is the time when students get interested and show aptitude and are either encouraged or discouraged to go ahead. This is really where we need to make a decided effort. As you know, many of the programs of the Foundation that your committee has backed very strongly deal with these questions of improving quality of instruction and early training in science.

That is where we need really to take important steps.

Dr. GROSS. Could I comment broadly on this thing?

I think the chairman's comment earlier focused on education.

Mr. THOMAS. Dr. Gross, you may proceed.

Dr. GROSS. As I see the situation, the Russian educational development really, as someone here commented, is a further move in the direction of a good European "continental" education. This type of education we all have respect for historically, and for its merits—which are real. The continental system has never, however, been broadly based so as to include large segments of the population. In England it has been largely confined to a limited number of people. By and large, these have been highly selected, good people. I think the danger from the Russian situation vis-a-vis ours is that they have taken the best elements of the continental system of education and applied them broadly to a huge population. This is where we face what many of us believe is a real challenge.

With reference to the echelons that one needs in science, I would roughly estimate these as three. There is the very brilliant genius, or near-genius. Such people are very badly needed in any country in connection with the future development of science.

Mr. THOMAS. And, you cannot tell from whence he is coming; can you?

Dr. GROSS. No, sir. The second echelon is a group of people of very high talent, and we have many of those in this country. Then, beyond these two categories in any development of science and technology of any magnitude for industry or defense in a nation, a third still larger in numbers is needed. These are scientists, shall we say, not at a routine, but at a working level in science who are required to staff numerous laboratories for research and development in government, industry, and the universities. Into this category there is in Russia a tremendous input of trained scientists from all the information I have and others have.

Mr. THOMAS. How do they compare in that regard with us?

Dr. GROSS. I do not think we are really as good in this particular direction as the figures of Dr. Kelly and others who are acquainted with the Russian situation indicate and as the studies the National Science Foundation has subsidized very clearly show.

Dr. WATERMAN. I agree that the U.S.S.R. is doing very well in this category. The Russians are making real progress. Our most critical need in the United States is to continue to improve our science education and to increase our effort. If we relax or become complacent as we are in danger of doing we can fall behind very quickly.

Dr. GROSS. I think the real danger is the large complex picture. The situation in Russia is not a new one, but it is an adaptation of the

continental system which has been shown to have very great strength, historically, but has been applied to broad populations in only a few instances. Even in Germany between the last two wars this reached relatively few people.

The outstanding professor at a typical German institute of physics—and I studied in one years back—paid attention to the brilliant half-dozen. The other students had relatively little attention paid to them.

I think the difference we are facing today in the case of Russia is that they have applied this system widely and backed it with federal funds, and liberal incentive rewards so that it now operates broadly throughout the population. I think this has relevance to your comment, Mr. Chairman. From such a situation where one does provide these facilities and buildings and teachers for large numbers of students, there is a high probability of having the emergence of highly gifted exceptional individuals. These are the scientists—few in number—who can show the way, so to speak, to breach the ramparts of our incomprehension of "inscrutable nature," and who lead the way to the new vistas and frontiers beyond. If we do not provide parallel opportunities, facilities, and good teachers for large numbers of students under our own system, I think we are in a very dangerous position.

Mr. THOMAS. We are depending upon Dr. Kelly and his staff, when he gets back to the office, to really spell out this problem in detail and, certainly, it should be emphasized and encouraged.

In other words, every student goes to school free of cost.

Mr. YATES. All the way?

Mr. THOMAS. All the way. But not only that, added incentives are given. The harder he works and more brilliant he is, he gets a little bit more than the echelon beneath him. It is subsidized from A to Z.

Dr. GROSS. And there is great rigor in the lower grade curriculum.

Mr. THOMAS. Excuse me for interrupting you.

QUANTITY OF OCEANOGRAPHIC RESEARCH

Mr. YATES. Dr. Stratton indicated that we were not nearly equal to Russia in terms of quantity, but we were seeking a preeminence in quality. I am not sure what is meant by "quantity." For example, I asked Dr. Revelle some questions with relation to oceanography research. The impression I received from him with respect to quality is that we are better or at least on a par with them.

Dr. WATERMAN. At the moment.

Mr. YATES. But that the trend is to the contrary, he said. The question I want to ask is with respect to quantity of oceanographic research. Have we made up our minds that we can compete more in terms of quantity of oceanographic research, or is this conclusion predicated on the belief that you do not need as much research?

Dr. REVELLE. I think the National Academy Committee, of which I am a member, would take the position that we should increase the quantity as well as raise the quality. Our proposals have been directed toward both these ends in the belief that we can do both.

Mr. YATES. We cannot do both.

Dr. REVELLE. That we can do both.

Mr. YATES. We can do both in the field of oceanography?

Dr. REVELLE. In the field of marine sciences, that we should do both.

Mr. YATES. In what fields are we inclined not to do both, or are we not seeking quality and quantity, or have I misinterpreted your statement?

Dr. STRATTON. No, sir. If I may, I would like to go back to the question on schools. My statement about quantity and quality comes down to this: There are two factors working against us. First, their total population is large and growing larger, and second (and more importantly), the Russians have a dedication and a conviction and feeling about the overriding importance of science and technology for their future that we do not fully share. I am not saying they are wholly right. This obsession for science and technology at the expense of other areas of scholarship may have long-term consequences that we cannot now foresee. But, we Americans are concerned with survival this year and next year and the year after, as well as with the long term. We have strong leaders in certain fields of science, such as oceanography and nuclear physics and in certain areas of biology, and in these fields we compete both in quantity and quality. Nevertheless, when one examines the average level of instruction in our elementary schools, our secondary schools, and even in our universities, it is difficult to believe that we are going to maintain our position with respect to the Russians in every field over any extended period of time. We do not enjoy at this moment equal resources in education. In short, I think it impossible for us to mobilize the equivalent amount of manpower in every field of science and technology as the Russians. It seems to me this leaves us only one alternative: To do superbly well those things we do undertake.

EVALUATION OF EDUCATIONAL SYSTEM SUPERIORITY

May I revert again to the question with which Mr. Thomas opened this hearing. It was the question whether our educational system is not, in fact, vastly superior to that of the Russians. I would like, if I may, to add this to the record.

Mr. THOMAS. We are delighted.

Dr. STRATTON. I share completely the views expressed by Dr. Gross, and I think they are completely sound. I too am aware of the increasing number of recent statements to the effect that the American plan of education is, in fact, superior to that of the Russians and we ought, therefore, to relax. I feel bound to contradict that view. We can by no means afford to relax. But this does not mean necessarily that we should adopt the Russian system for our own. I do not think that there is any such simple solution to our problem. A system which may be advantageous for a people brought up in the continental tradition and which may work under a government with totalitarian authority cannot be transferred intact to the United States. Our system of education is indigenous to the United States and is based on the ideals and the history of our country; it draws upon our traditions and background and is related to the things for which we stand. To this extent I do defend the American system against the Russian. But on the other side, and against all those who view our present situation with complacency, I must say that it seems to me that we lack in this country the intensity of feeling of the Russians about the

role of education and the essential conviction that education and science are of overriding importance for our national survival. We fail also to recognize that we are in competition not only with Russia and China but must soon meet a new kind of competition from newly emerging countries all over the world. Even if there were no Russia, the requirements for economic survival would demand a program of education and research such as has been undertaken by the Foundation. That program must eventually reach down into the secondary and elementary schools all over the country.

Finally, I would like to make one other point.

PROPER BALANCE IN AMERICAN EDUCATIONAL SYSTEM

It happens that I represent a technological institution, and my professional life has been concerned with education in science and engineering, but by no means do I believe that the sole key to the survival of the United States lies in a complete concentration on science. It would not be in our best interest to convert the high schools completely into institutions of scientific training. That is what the Russians have done in very large measure. We must seek a proper balance. There is, in my opinion, need for a great deal more science in secondary and elementary schools. They must be taught more intensively than is now generally the rule, but the aim of these studies should not be merely to produce scientists and engineers. A knowledge and understanding of science must have an increasing part in the education of all people who live in this modern world.

Mr. YATES. I wonder if I may continue with regard to your last statement. When you said what the Russians have done to a large extent is to convert their schools to science, the fact remains that the Russians are also studying languages, and that they are studying social sciences as well.

Dr. STRATTON. Yes. In the field of linguistics, for example, they appear to be doing superior work. From all that I can ascertain, their work in linguistics is outstanding. But although they do study languages intensively, it is my impression that their interest is one of utility rather than a literary interest.

Mr. THOMAS. Their interest in languages is geopolitics. They want the language so that they can understand the geography and the economics of a particular country of the world.

Dr. STRATTON. It contributes to their main goal.

QUALITY AND QUANTITY OF RESEARCH

Mr. YATES. Continuing my questioning on this question of quantity, do I understand your argument to be that we cannot compete in the quantity of personnel? Is there any reason why we cannot compete in the quantity of funds set aside for the purposes of scientific research?

Mr. STRATTON. There is no reason why we cannot compete in that.

Mr. YATES. Insofar as the activity in the scientific community is concerned where we are engaged in polar research, geophysical studies, astronomy, mathematics, marine sciences, and so forth, how do we rate quantitatively with the amount of research they are engaged in?

Dr. Revelle indicated that their program is more extensive than ours, but that we hoped to catch up. What is the status of the other pro-

grams? Are they conducting much more extensive scientific programs in the other sciences as well?

Dr. GROSS. As one looks at the literature of science—the published papers—one has to be very careful not to use numbers alone, as the sole criterion. Nevertheless, from an earlier position where it was not important for a scientist in the general sense in any particular field to know Russian as a working language to understand science in this area, the importance of the Russian language as a working tool of scientific knowledge is now in a position where it is probably second to English. There was a time when the German language was second to English, or still earlier when the English language was second to the German language. I think the others will confirm my view about this. Is that not about the picture?

Dr. KELLY. That is certainly the trend.

Dr. GROSS. I do not say that I have answered your question, but I do say there is a very steep rise in the contribution to science by Russians if one looks over a period of time, of say, 20 years.

Mr. YATES. You have emphasized the importance of the Russian language in the scientific field. I was seeking a much more factual answer, if one is available, and that is with respect to the question as to how much Russia is doing in individual fields of science in relation to what we are doing in those fields. Do we have such information?

Dr. WATERMAN. We do. I spoke a little of that previously.

Mr. YATES. You talked about the quality in those individual fields and not the quantity.

Dr. SEARS. The last time I saw a personnel directory of the field of climatic history in which I am interested, there were several times as many Russian as United States workers listed.

Mr. YATES. Does this mean that because of the number of people trained in the field their quality is better?

Dr. SEARS. Their quality is very good.

Mr. YATES. The quality is good, but what about the quantity of the research itself? Does it keep pace with the number of personnel?

Dr. SEARS. I would say so.

Mr. YATES. Is this true of all the fields?

Dr. SEARS. That is the only field that I can speak of.

Dr. WATERMAN. By and large that is true; the quality is keeping pace with the number of trained personnel.

Mr. OSTERTAG. I think that any one of you can answer this question. It is a little bit difficult for me to get a perspective with regard to quantity. I can understand what you mean when you talk about quality in research, particularly when we are talking about unknown quantities. If we mean in basic research something that we have not found but we are seeking, then how do you measure quantity in connection with that? Is it numbers of people and hours of effort, or is it dollars, or is it a combination of those things?

Dr. STRATTON. When I spoke of quantity I was referring to the number of people in any given level of training. It was not on the basis of dollars but of people. I doubt very much whether we would be wise nationally to convert the proportionate number of our total population to these endeavors because I think in the long term other things will suffer.

Mr. BOLAND. We do not have to do that.

Dr. STRATTON. We do not have to do that. But what we do, I say we must do superbly well. That does not mean we should not spend the money, I think that we should spend the money, but in accord with some thoughtful plan. We recognize we cannot do all things but what we do we should do outstandingly well. This is true whether we do it in education, or in research or in engineering.

Mr. YATES. What you are saying is the Russians are doing it superbly well because, according to Dr. Revelle, their work is of the same quality as ours. They have numbers in addition to the superb quality.

Mr. OSTERTAG. Quantity and effort would mean the same. The degree of effort would be the yardstick of quantity.

Dr. STRATTON. The degree of effort, yes. This is a subtle matter. It does not necessarily mean that because you put a lot of people on a project and a lot of money in a project you make very much advance. Our only defense is to wisely use well-trained people—and give them enough resources to do the things that are most important.

Mr. OSTERTAG. We have been using the words "quality" and "quantity" here in its relationship to science. I thought a little clearer point on the quality of quantity was important.

IMPROVEMENT OF SCIENCE EDUCATION

Mr. BOLAND. In the field of education are you satisfied with the stimulus that the Nation has provided through the Federal Government or State and local communities? Are you satisfied over the last couple of years with that stimulus? Are we meeting the challenge? What do we lack and what must we do?

Dr. WATERMAN. It is not nearly enough with respect to the teaching of science. There you have the old problem of what do you do about the position of the secondary school teacher of science. You cannot get good teachers—or good people in any field—without incentives, and salary is one of the important incentives. A person has to have a competing wage or he will not go into the work. You cannot blame him. For a half dozen years at least there has been talk about what we can do about raising teachers' salaries in the secondary schools. Nothing much happens except in a few localities where the citizens get excited and do something. That is a very serious question. It goes to the heart of the whole thing. There is not only the question of salaries; teachers must also have opportunities for advancement, better community status, opportunity to study their subjects and keep on top of them—all the things that go into making a career attractive.

We have tried to meet the problems of science education, as you know, in several ways. Below the college level, several areas need improvement. Students in the schools must know what science is so that the right ones will be properly motivated to continue in it. In this area we have visiting scientists, traveling science libraries, summer training for secondary school students, and other programs. The results of these experimental programs seem to be very good. The support provided by this committee to the programs for supplemental training of science teachers is paying off in a most satisfactory way. Teachers in other fields, and school administrators, are seeing the

value in such additional subject-matter training, and I believe that these efforts will help to strengthen the entire educational system. Another large area is course-content improvement. When we have well-trained teachers and students who are interested, then it is vital that the science they study reflects the status of science as it is now. The effects of our efforts—notably in high school physics, which is farthest along—are being reflected surprisingly soon. It is a complicated business to get such new and unfamiliar materials into the curriculum, but it is beginning to happen, and according to indications the speed will pick up rapidly. We are working toward improvement of the whole picture of science education—not just a piecemeal approach.

Mr. OSTERTAG. Has the Defense Education Act had any effect on this?

Dr. WATERMAN. Certainly. So has our activity at NSF. The efforts of the Office of Education and of NSF are both very helpful and complementary. But we do not see yet that the teachers' salaries have been raised to compete with other jobs. Many secondary school teachers have to get a job in the summer to make ends meet. Incidentally, we have not talked very much about the quality of our teachers in terms of preparation for science teaching. This is one of the key points. It is one thing to say that a certain number or percentage of students is studying science in the United States as compared with Russia. It is quite another thing to try to compare what they learn. An important factor here is the preparation of teachers as far as subject-matter knowledge is concerned. The staff has some material on this subject. Mr. Chairman, would you like Dr. Kelly to speak briefly to the subject of teacher preparation at this time?

Mr. THOMAS. This is a part of the general question that we are interested in. Will you also have something for the record on this topic, Dr. Kelly?

Dr. KELLY. We can prepare quite a lot of material for the record, and I can provide some of the highlights now.

Mr. THOMAS. Go ahead, Dr. Kelly.

Dr. KELLY. We have placed a heavy emphasis on the subject-matter preparation of our science and mathematics teachers as an important key to the quality of instruction that our students will obtain. We feel that we still have a long way to go, but the results of the general effort in the country along this line—including our own programs—are highly encouraging. Most encouraging is the response of the teachers themselves. They are taking advantage of opportunities to improve their knowledge of the subject they teach. They are identifying themselves as a part of the scientific community and already within the space of 4 or 5 years I think we can see a really significant improvement in science and mathematics instruction at the secondary-school level. This does not mean that the task has been finished. It means simply that we have found effective ways to meet a fundamentally serious problem. One of the most important things is that communities, States, and Federal agencies sustain the support that these teachers have been receiving so that they can continue to improve their teaching effectiveness.

Mr. THOMAS. We must have confidence in the people who are working hard to improve our whole educational system.

Dr. KELLY. This has been the basis for our entire effort, Mr. Chairman. I have some information here about teacher preparation which I should like to summarize very briefly, if I may, because I think it will help to put this whole problem into a better perspective.

Mr. THOMAS. Go ahead, Dr. Kelly.

Dr. KELLY. In the first place, the science teacher situation is quite different in the two countries. Since science is taught formally beginning in the fifth grade in Russia they use a larger number of specialized teachers than we do at present. In the U.S.S.R. there are well over 400,000—nearer 425,000—teachers of science subjects in grades 5 through 10 or 11. We estimate that in this country about 150,000 teachers teach these subjects in the junior and senior high schools.

A larger percentage of our science and mathematics teachers have completed 4 or even 5 years of college. In most States, a degree is now required to begin teaching at the secondary-school level; in some places a master's degree is required. In terms of degrees, therefore, U.S. teachers may be considered to have met fairly high standards; as I shall point out later, however, their subject-matter preparation often leaves much to be desired. On the other hand, probably only one-half of the present group of science and mathematics teachers in the U.S.S.R. have completed 4 or 5 years of higher education. Many of the others have had a 2-year institute course, and about 10 percent have not had more than secondary-level training.

The regular pedagogical institute 5-year training program in the U.S.S.R. is impressive. Nearly two-thirds of the instruction of mathematics and physics teachers will be in the two subject matters and related technical training. In the United States, teacher training is carried on by the universities, liberal arts institutions and teachers colleges. The individual States set up qualification requirements, and there is great variation throughout the country. There is growing improvement both in State certification requirements and in the graduation requirements of the colleges and universities as far as preparation for secondary-school teaching in science and mathematics is concerned. For example, even though certification still requires a considerable number of credit hours in pedagogy—some of which is essential—an increasing number of colleges and universities which prepare high school teachers require at least a major and a minor in teaching fields—in this case science or mathematics. For elementary school teachers it might be three minors in subject-matter fields related to the subjects taught in the elementary schools. The principal problem here is similar to that in all other aspects of science education. We must continue to stress the quality of science instruction—in this case for prospective teachers. There are many evidences that here, also, the scientists and science teachers responsible are making progress.

As far as our inservice teachers are concerned, they are among the first to agree that most of them need additional training in the subject matter of science itself. Some completed their formal education years ago when requirements were less stringent—and they had actually very little formal training in science or mathematics. Some have been converted from other fields, and their formal training in science is generally quite weak. Many others, originally well trained, have not had opportunity to bring their knowledge up to date.

We completed a staff study a few weeks ago in which it was estimated that there have been approximately 75,000 enrollments in NSF

programs for this type of training between 1954 and 1960. About 30,000 teachers will participate in these programs this year alone. Of course, there are duplications in these figures, but many teachers need a combination of these courses in order to fill out their training and bring themselves up to date.

There are a number of problems in this connection that we are studying. Nowhere nearly all of our high school science and mathematics teachers have been able to supplement their training to the desired level, and the introduction of new course content materials will create new problems for a great many teachers. While our ultimate goal is to be able to reduce these programs, it looks now as if our support must be sustained. We cannot afford to let down just because we begin to see some good results. We are, however, as you will note in the justification, making some adjustments in emphasis among the programs for supplemental teacher training in order to achieve the best results that we can.

Mr. THOMAS. Thank you, Dr. Kelly. Will you have your notes expanded for the record?

Dr. KELLY. Yes, sir.

(The material requested follows:)

SCIENCE AND MATHEMATICS TEACHERS AT THE SECONDARY SCHOOL LEVEL

The U.S.S.R. system of specializing in science and mathematics instruction at grade 5 requires a substantially larger number of specialized teachers of those subjects than the U.S. system. About 427,000 such teachers are employed in U.S.S.R. grades 5–10(11) while an estimated 150,000 specialized teachers of science and mathematics are employed in U.S. junior and senior high schools (grades 7–12).

Nearly all of the 150,000 U.S. high school teachers of science and mathematics have completed at least 4 years of higher education and many of them 5 or more. In contrast, about one half of the U.S.S.R. science and mathematics teachers, who are somewhat better prepared than the other teachers, will have completed 4 or 5 years of higher education—but this means over 200,000 Russian teachers are trained to this level. Many of the science and mathematics teachers will have a 2 year institute course, and perhaps 10 percent not more than secondary school training.

The regular U.S.S.R. pedagogical institute training program of 5 years is an impressive one. Nearly two-thirds of the instruction of mathematics and physics teachers will be in the two subject matters and related technical training. Teacher training in the United States is carried on by the universities, liberal arts institutions, and teachers colleges. Length and character of training is determined by the State certification authorities and the institutions. It is generally believed that most of our science and mathematics teachers are in need of additional subject-matter training. Relatively large efforts to help ameliorate this situation are now being made in various ways; one of the significant activities in this direction is the program of teacher training institutes being sponsored by the Federal Government through the National Science Foundation.

TRAINING OF SCIENCE AND MATHEMATICS TEACHERS IN THE UNITED STATES

It is estimated that there are almost 1.6 million elementary and secondary school teachers in public and private schools of the United States. Of these, almost 1 million are elementary school teachers; few if any of these teachers can be called science or mathematics teachers. Our system of elementary education, particularly at the lower grade, is such that in most cases elementary grade teachers teach all subjects. The amount of stress placed on the teaching of science and mathematics depends on the orientation of the school administration and the competence of the teacher.

Of the 600,000 high school (including junior high) teachers in the United States, about 150,000 are teaching courses in science or mathematics. About one-fifth of them teach both science and mathematics; about one-third teach

science but no mathematics and about two-fifths teach mathematics but no science. About half of the science and mathematics teachers devote full time to the teaching of these subjects.

PREPARATION OF SECONDARY TEACHERS

There are, of course, no national standards or preparation requirements for secondary-school teachers. In most cases the State and local jurisdictions certify teachers and set other conditions of employment.

The National Education Association also reported that about two-fifths of high school science teachers, and about three-fifths of high school mathematics teachers had taken fewer than 30 college semester hours of science and mathematics, respectively.

Last year the Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science issued a report in which it recommended that essentially one-half of the undergraduate course work of science and mathematics teachers be in science and mathematics, and that a half of this, in turn, should be in the specific field (say, physics) taught by the teacher. For example, it was recommended that:

The high school teacher of biology take a total of 59 college semester hours of science and mathematics, broken down by 30 in biology, 23 in other sciences, and 6 of mathematics;

the high school teacher of chemistry take a total of 59 college semester hours of science and mathematics, broken down by 28 in chemistry, 19 in other sciences, and 12 in mathematics;

the high school teacher of physics take a total of 60 college semester hours of science and mathematics, broken down by 25 in physics, 22 in other sciences, and 13 in mathematics;

the senior high school teacher of mathematics take a total of 48 college semester hours of mathematics and science, broken down by 30 in mathematics and 18 in science; and

the junior high school teacher of mathematic take a total of 36 college semester hours of mathematics and science, broken down by 24 in mathematics and 12 in science.

When the NEA data on preparation of teachers mentioned above are analyzed against the backdrop of the AAAS committee recommendations, it is found that at least two-fifths of the high school science teachers and one-half of the high school mathematics teachers do not meet the recommended minimum requirements.

Currently, there are several programs aimed at improving the quality of the Nation's elementary and secondary school teachers. Some are supported by the Federal Government, some by individual States, some by professional organizations and some by teachers themselves.

The following are examples of some of these items.

There has been a widespread effort to enlist the cooperation of liberal arts staff members in planning teacher education programs and in formulating State certification requirements.

There has been a great improvement and modernization in course content, much of which work has been supported by the National Science Foundation (such as that of the Physical Science Study Committee at the Massachusetts Institute of Technology, the School Mathematics Study Group at Yale University, and others).

There have been substantial programs for the supplementary training of teachers—e.g., the summer, academic year, and inservice institutes program of the National Science Foundation.

There has been a movement toward the establishment of prerequisites for membership in professional associations.

There has been a continual increase in the number of States enforcing the degree requirement for regular certification of beginning elementary teachers. In 1937 only 6 States were enforcing this requirement. As of July 1, 1959, 40 States were so doing. As of 1960, all States are enforcing the minimum requirement of a bachelor degree for all high school teachers.

SCIENCE AND MATHEMATICS TEACHERS IN THE U.S.S.R.

Science and mathematics are taught as separate subjects by specialized teachers at grade 5 and above in the U.S.S.R. This earlier specialization and the greater emphasis on science and technical subjects require more teachers of

science and mathematics in the schools of general education than in this country. An estimated 427,000 were so engaged in the academic year 1959, according to Soviet sources.

Teacher training in the U.S.S.R. is now in the process of change in accord with the educational reform program. Secondary school teacher (grades 5–10) training is now expected to consist of 5 years of higher education, i.e., beyond the grade 10 or 11 levels of the general schools. This contrasts with a previous level of 4 years beyond the 10-year school. Training is provided by teachers' colleges (pedagogical institutes) and universities.

About half of the science teachers now in service have completed full higher education training of 4–5 years. About 40 percent of them were trained in teachers' institutes (probably many of them in the earlier 2-year training course) and the balance were otherwise trained, largely to the secondary school level only. The table below shows a percentage distribution of teachers according to training level and type of school. (See table 1.)

TABLE 1.—*Percentage distribution of science and mathematics teachers by level of training and grade levels, 1959, U.S.S.R.*

Subjects	Grades 5–7				Grades 8–10			
	Total	Higher education	Institute education	Other	Total	Higher education	Institute education	Other
Total	100	31	56	13	100	85	14	1
Physics	100	42	45	13	100	88	11	1
Mathematics	100	28	57	15	100	85	14	1
Physics and mathematics	100	17	69	14	100	73	25	2
Chemistry	100	48	42	10	100	92	7	1
Geography	100	53	38	9	100	88	11	1
Natural science	100	36	51	13	100	82	16	2
Geography and natural science	100	17	71	12	100	64	33	3

Source: U.S.S.R. official publications.

On the whole, the U.S.S.R. science teachers at the level equivalent to the U.S. senior high school appear well qualified. For the most part, they are trained at the level of higher education.

Although the 5-year pedagogical institutes programs of teacher preparation include required courses in what might be termed "Marxism" (history of the Communist Party, dialectical and historical materialism, etc.) pedagogy, and classroom practice, the bulk of the programs consists of strong subject matter courses in the subjects to be taught. These are supplemented with some electives, and these too are likely to be closely related to the major field. Below is a summary of a 5-year pedagogical institute program for prospective mathematics and physics teachers showing semester hours of instruction by general subject matter:

Training courses for mathematics and physics teachers—U.S.S.R.	Semester hours	Percent
Total	320	100
Mathematics	103	32
Physics	60	19
Pedagogy, including teaching methods, psychology, etc.	57	18
Technical, mechanical drawing, mechanics and machines, metals and materials, shop practice	40	12
History of Communist Party, dialectical and historical materialism, political economy	37	12
Miscellaneous physical education, school hygiene, foreign language, etc.	23	7
Teaching practice	(1)	

[1] 18 weeks.

Source: U.S.S.R. official publications.

According to this program, nearly two-thirds of the 5-year training can be classified broadly as mathematics, physics, or related technical subjects.

Mr. BOLAND. The challenge alone is not in the secondary schools, it is in the elementary schools also. This is the place where we ought to give tremendous emphasis. The National Academy of Sciences put out a publication "Planet Earth." I sent some of them to some high schools and grammar schools. The replies that came back indicated that they were well received by the children. Their enthusiasm has been touched. Their interest has been sparked. I think this is the place that you have to do it. I have been saying this for years; if we are going to have any love for mathematics or the more difficult fields this is something which has to be done for the dedicated teachers and the elementary schools.

NUMBER OF SCIENCE TEACHERS LEAVING TEACHING PROFESSION

Mr. JONAS. Dr. Waterman, have you developed any statistics that will show the extent to which our secondary education teachers in the field of science are leaving the teaching profession?

Dr. WATERMAN. Yes, indeed.

Mr. JONAS. What do they discover or disclose?

Dr. WATERMAN. In a recent year there were something like 3,600 teachers fully trained for secondary school science. Only a little more than half of them actually took employment as teachers in the secondary schools. Being trained in science, many got better jobs. This left science teachers short by about 1,200 and required hiring a goodly number who were not fully qualified.

Mr. JONAS. Is there any greater turnover in that field than in any other field of endeavor? We have a tremendous turnover in Government.

Dr. WATERMAN. I do not know how to compare this because I do not know the figures for the others.

ROLE OF NATIONAL SCIENCE FOUNDATION IN IMPROVEMENT OF PRIMARY, ELEMENTARY, AND SECONDARY SCHOOL CURRICULUMS

Mr. JONAS. I have asked this question each year, I think—what efforts are you making with the State school commissions to induce them to beef up the curriculum in the primary, elementary, and secondary school levels?

Dr. WATERMAN. We do not deal with the State boards of education because this is the province of the Office of Education. Instead we deal directly with training centers such as colleges that will establish summer institutes or in other ways help with these problems.

Mr. JONAS. We have explored that before. We agreed that your act is broad enough to permit you to deal with that subject with State school commissions. The conversation we hear in here each year is that our curriculum at the secondary and elementary level is not strong enough; that we ought to begin putting more emphasis on science at those lower levels. Yet what, if anything, is being done to try to stimulate an awareness of that problem where it counts—in the State capitals of the 50 States?

Dr. WATERMAN. We are doing a great variety of things, a lot of them experimental, and those that succeed are expanded so as to make people, including school boards, aware of solutions to this problem.

We have visiting lecturers, traveling libraries, and a number of other programs which reach teachers and students at this level.

Mr. JONAS. I understand all that. That is a part of your program. We have been trying to step it up each year, but I understand from the testimony we hear that nothing is being done about it at the State and local levels. That is where something has to be done. We cannot improve the quality of education at the top level, we have to start at the beginning now. It is somebody's responsibility to bring these people together in regional conferences, or in State conferences, or in a national conference and talk it over to see what their ideas are and whether we cannot induce them to begin a program of strengthening these curriculums.

Dr. KELLY. We are concerned about this. We have adopted the principle that we should support the leading scholars in the field concerned with the curriculum to work with the high school teachers. They have for several years now been working on these and now have produced new textual material in physics and mathematics. Work is going on in biology and chemistry. We also make the assumption that the responsibility of developing interest in association with the State departments of education is the responsibility of the college or university to whom we are making the grant. This, I think, is turning out right.

In your State of North Carolina, next month, I believe, there is a meeting to be held where the people from the State department of education and departments of education in the various colleges and universities have invited the leaders in physics and biology and mathematics. They are to report and determine how they can integrate the new curriculum into the school system. This is also happening in several other States. I just came back from Wisconsin and they are doing the same thing there.

Mr. JONAS. All that is well and good. I still have difficulty in understanding why, when you have these meetings, the members of this Board or some of your experts who are aware of this problem and who are familiar with the situation on the continent and who come in here and tell us we are falling behind in these fields and that the quality of education in some other country exceeds ours, what is to prevent you from going down there and giving the information you give us to the State school people.

Dr. KELLY. They have invited us, our efforts to improve the content of science courses has been limited to support of the research and exploration stages—by supporting the development of texts, films, and laboratory apparatus by leading research scholars working jointly with able teachers. We do not support the production or distribution of these materials. If they are as good as we think they are, they will sell themselves.

Mr. JONAS. We have been discussing this subject for several years now. Has any progress been made in the United States at the secondary school level in increasing the quality of the school curriculum?

Dr. WATERMAN. Yes, indeed. We have a very strong program in that.

Mr. JONAS. How does it work? That is what I am talking about. What evidence do you have that it is succeeding, or improving?

Dr. WATERMAN. In these particular fields in the elementary schools and secondary schools (physics, chemistry, biology, and mathematics) we have an extensive program of what we call course content improvement. For this we get together with the supervisors of the elementary schools and present this material to them.

Mr. JONAS. You say that we get together.

Dr. WATERMAN. With the Foundation. We make grants to get these people together to discuss how the course can be improved in content. We do this very extensively with the secondary school people.

Mr. JONAS. Do you tell us there have been some results from those efforts and course content has been improved?

Dr. WATERMAN. In this year's program we are reaching something like 2,500 teachers of science in the secondary schools.

Mr. JONAS. What I am hoping you are doing is that in some of your conferences, and in some of your discussions with the people who decide upon the curriculum, that you are encouraging them and that you can tell us that we are making some progress in improving the quality of course content at the secondary level.

Dr. WATERMAN. All we feel we should do is to do what we can to be sure science teaching is improved. We cannot very well tell them what to cut out. So, if you are talking about changing the entire curriculum, that really is not our business. What we are trying to make sure of is that science is well taught, and that the materials are available, and all that is necessary to improve its teaching.

I would like to emphasize that there is great interest in the science and mathematics curricula on the part of local superintendents and principals—this we see in their discussions at their national meetings—and especially on the part of the science and mathematics teachers themselves. Many local school systems are at work now in trying to improve their own curricular materials, and are taking advantage of new materials from such projects as the ones we have supported as soon as they become available. I believe that a strong movement here has been started. It will take some time for the changes to show up in the training of college students, but this is on the way. The important thing now is to be certain that support for these efforts is continued so that the momentum and enthusiasm will not be lost.

Mr. JONAS. I hope you will not be too squeamish about what your jurisdiction is. I would like to see some aggressive action taken and let somebody else question whether you have jurisdiction in that field.

Mr. YATES. Jurisdiction over what?

Mr. JONAS. Education, stimulation and promotion of science.

Dr. STRATTON. I feel, Dr. Waterman, you should give a categorical yes to Mr. Jonas' question, though you are right the Foundation has not gone in and said that you cannot do something. The Physical Science Study Committee has made a dramatic change in the secondary school curriculum in physics. This is spreading to mathematics and science, and enormous progress has been made in showing what can be done. Maybe this is not the final answer, but for about the first time in our educational history there has been a break from a traditional approach to something that is really new and worthwhile. I think that the National Science Foundation should take credit.

Mr. BOLAND. I think so too.

Mr. THOMAS. You have implemented that program now for 2 years and you either ought to take credit or you ought to throw the program out.

Dr. WATERMAN. I intend to give a categorical answer. We are really doing a great deal for science teaching in all schools. The results are good.

Mr. JONAS. I wanted the record to disclose some concrete results. We have a statement that we are making progress and that we are doing everything we can to stimulate that.

Dr. SEARS. I think the figures as to the number of high schools that the revised mathematics program is being tried out next year will be very helpful in that connection. That is specific.

Dr. GROSS. I would agree with that. I would agree with you about not being too squeamish about who is doing it. The NSF needs to move into this and really tell the people that here is a program of great validity. I think Dr. Kelly in his program is moving strongly in the right direction.

Recently we heard, for example—and this happened locally in my own institution—a discussion of Russian scientific education. Now we have a changed attitude among our educators themselves toward this problem. I still agree with you we are going to have to continue to make an impact on this whether it is jurisdictional to NSF or not. That is my own feeling about it.

Mr. THOMAS. We have another very distinguished Board member here who has not said a word, Dr. Volwiler.

We want everybody to very carefully edit his remarks and we are going to lean very heavily on you, Dr. Kelly. We are going to print some five to ten thousand copies of the preliminary remarks, particularly where you are dealing in the broad field of education and the comparison between U.S.S.R. and the United States.

Dr. VOLWILER. I have been listening with a great deal of interest to the comments and particularly to the questions, which are very important leading ones. It has taken a great deal of time to make somewhat of a turnabout in this matter with the so-called progressive education being pretty much in control. I can support what has been said by the other members of the Board and what you men on the committee have brought out, that the Foundation has quite effectively directed its attention to the encouragement of basic education leading to scientific careers. An effective start has been made. A great deal more needs to be done. It is not clear to what extent the cooperation of many influential people in education can be enlisted. I believe that the type of training for the teaching of science mentioned by Dr. Waterman is going to be very important in furthering this trend.

Mr. THOMAS. Dr. Waterman.

Dr. WATERMAN. If I may I should like to conclude my opening statement. You remember, I spoke about the need that has developed more and more strongly for encouraging the strengthening and development of our educational and research institutions. We have in the past paid attention to the progress of science in a big way in the Federal Government and the development of individuals that are concerned, but the institutions have found themselves with a lack of flexibility and difficulty in strengthening their overall scientific work on their own, which is one thing about which we are concerned.

With the idea of improving the flexibility of what an institution can do in science, and to compensate for the support which is earmarked for a particular research project, even though some of these may be broad, what we want to institute is to provide from our research fund in a lump sum to the president of the institution 5 percent of the actual grant money which has gone to the institution say for a year. This would be used by the president in any way he chooses with respect to scientific activities and not for indirect costs.

It is a very simple thing to do. It does provide a degree of flexibility which is badly needed at the moment, and furthermore, this is an experiment that can be watched. We will have a report on what each does with it and see how it works. If it does not work, it is a thing that can be stopped easily, or if successful it can be expanded to some extent. This we would like to try as an experimental program.

You will notice that this would not change the distribution of Foundation money at all because each institution would get money in proportion to the grants which we make to them. So it does not change the distribution to the institutions in any way.

Mr. YATES. May this be used for salaries of members of the staff?

Dr. WATERMAN. Yes. It could be used as they see fit. We feel that this is a badly needed move at the present time. It has the approval of other Federal agencies. This would be just in science.

By way of summary, we believe thoroughly—and our Board is unanimous in its views—that the Foundation is in position to render a distinct and timely service to the country by the programs that appear in the budget request before you. We firmly believe that these are "musts" in order to meet the urgency of the situation that we face. We feel we cannot jeopardize the future of the country by failing to provide support and encouragement along the lines which we have indicated.

Mr. THOMAS. Do any of the Board members have any observations to make?

Dr. SEARS. May I introduce a footnote? I do not think we ought to feel any effort to improve science education for women is wasted regardless of whether they go into science as a career or not. My observation has been where mothers have some understanding of science it is a potent factor in interesting the next generation, so keep that in mind.

EMPHASIS ON QUALITY AND QUANTITY OF GRADUATE SCHOOLS

Dr. REVELLE. I would like to introduce a caveat. I would like to get in one note of alarm. It seems to me that we must always keep in mind that we have to have a balanced educational program. You do not make scientists in either the primary schools or the high schools. You make them in the colleges and graduate schools. It does not matter very much where a kid's education starts. What is very important is where it ends up. I am more disturbed about the quality and quantity of our graduate schools than I am about the quality and quantity of our elementary schools, our elementary scientific endeavor.

Mr. THOMAS. You have to start them before they can get to that university or the graduate school.

Dr. REVELLE. That is correct. You can have science teaching running out of your ears in the high school and never produce a single scientist. You really have to do this at the graduate level. When we talk about the quantity of scientists, one way to judge it is by the number of Ph. D.'s turned out each year, because it is really only the Ph. D.'s who are capable, on the average, of doing independent scientific research, a man who has had the education and experience and has demonstrated the talent to do this extremely difficult job of finding out the truth.

The fact of the case is you can practically count on the fingers of your two hands and toes of your feet the number of universities in this country which are engaged in good research and which are turning out significant numbers of educated scientists.

It seems to me this question of the support of our graduate schools and universities in scientific education should be given perhaps even more attention than the sort of background education that is required in the elementary school and high school.

Mr. JONAS. You say that only a Ph. D. is qualified to engage in research. I think the record will show that we have produced some pretty important scientific discoveries by people who never saw the inside of a graduate school.

Dr. REVELLE. That was certainly true in the past, but it is becoming more and more difficult, but certainly not impossible, because of the increased specialization and the increased level of knowledge and experience that is required.

Mr. YATES. It is not a fact that the people that Mr. Jonas speaks of were applied scientists rather than basic research scientists?

I think perhaps he might have been referring to Thomas Edison, or some of the other inventors. I think they were primarily applied scientists.

Dr. REVELLE. Michael Farraday had little education and he made some very basic contributions to science. Michael Faraday without an education today would have great difficulty.

Mr. JONAS. Because of a lack of opportunity?

Dr. REVELLE. Not at all, because of the fact that you just need to know a lot and have to be in the environment of research.

Mr. THOMAS. We have had a great deal of discussion and a great deal of information provided here this morning. Is there any final statement you would like to make on the subject of education?

Dr. WATERMAN. I would like to say only this. I fully agree with Dr. Revelle on the importance of graduate education, and we must do everything that we can to strengthen it. We must, nevertheless, look at the whole picture of science education and be sure that it is strengthened all along the way. While our situation with respect to education in the sciences and engineering is serious, it is by no means hopeless. We see the beginnings of a strong and positive response to the generally recognized need for improvement. It is a good thing that our educational process has been sharply criticized, and that solutions of many kinds and degrees have been proposed. Out of all this has come a general movement which we feel is in the right direction. In the areas which we have supported through our programs, for example, there has been a very positive response. Teachers are eager to improve their knowledge of science and mathematics and to incor-

porate this knowledge into their teaching programs. Schools and teachers wish to adopt better and more realistic course-content materials as they are being produced as a result of our own efforts and others. Students at all levels appear to be responding. They are enrolling in science and mathematics and are eager to attain good academic standing. I do not wish to express a false note of optimism. It is important to emphasize that we have made an excellent start, but it is still only the beginning. During these past few years we have found numerous effective ways to improve science education, and it is most important that the knowledge and experience gained be employed to maximum advantage. There are still other problems which we are just beginning to attack. One that we are thinking about now, for example, is the increasingly serious problem of laboratory facilities and equipment in undergraduate teaching laboratories.

Earlier this morning, Mr. Yates requested information on scientific personnel and training in the Soviet satellite countries. If it is satisfactory, we will submit some material on this topic as it relates to the Sino-Soviet bloc of nations and the free world.

Mr. THOMAS. That will be fine.

(The information requested follows:)

SCIENTIFIC AND TECHNICAL PERSONNEL RESOURCES IN THE FREE WORLD AND SINO-SOVIET BLOC[1]

The comparative situations in the Sino-Soviet bloc and the major free world nations with respect to scientists and engineers may be briefly summarized in the following terms. The free world has currently a large base of trained scientific personnel resources; however, through concentrated and coordinated effort, the Soviet block is increasing its resources. The European countries of the free world, though having a lead in the beginning, are not moving as rapidly to expand as appears desirable. Communist China has within a few years achieved considerable progress in developing scientific manpower resources and can be expected to continue this effort.

The scientific and technical personnel resources of the free world nations outnumber these of the Sino-Soviet bloc countries by roughly one-third. Available data, which are greatly lacking in comparability as to time and concept, indicate in round numbers that the free world has an estimated 3 million scientists and engineers (about two-thirds engineers) and the Sino-Soviet bloc has an estimated total of 1,900,000 (more than two-thirds engineers). In general, these data include all such personnel at the bachelor's degree level or higher in the physical and life sciences (agricultural, biological, and medical) and engineers. Medical personnel engaged in care of patients are not included. Among the free world nations, the United States has the largest number, with about 30 percent of the scientists and over 40 percent of the engineers. In the Sino-Soviet bloc, the Soviet Union has the preponderance with over 75 percent of the scientists and nearly 75 percent of the engineers.

While the United States and U.S.S.R. possess by far the principal resources of scientific personnel in their respective groups, significant numbers are being trained in some of the other nations. In the free world, the United Kingdom is graduating about 20,000 scientists and engineers each year, France produces some nine to ten thousand, West Germany 15,000, and other nations, including Italy and Canada, are important contributors to the total. In the Sino-Soviet

[1] Free world nations are herein defined to include all those nations not specifically committed to the Sino-Soviet bloc. For practical purposes, however, scientific and technical personnel resources and training are largely concentrated in a small number of them. These nations include the United States, United Kingdom, France, Federal Republics of Germany, Canada, Italy, Norway, Sweden, Denmark, Belgium, Netherlands, Greece, Switzerland, Australia, New Zealand, India, Japan, and Israel.

Sino-Soviet bloc nations include the U.S.S.R., Communist China, Bulgaria, Rumania, Hungary, Czechoslovakia, Poland, East Germany, North Korea, North Vietnam, and Albania.

bloc, Communist China easily leads the satellites in the number of engineers being trained. Czechoslovakia, East Germany, and Poland are among the satellite countries with important training programs.

It is difficult to find valid generalizations applicable to scientific and technical personnel resources in these two groups of nations. Each group contains countries with greatly different traditions, resources, and outlook. Each group contains some nations strikingly akin to countries in the opposite group in terms of level of living, stage of industrialization, demographic composition, etc.

One generalization, however, does appear true with respect to both groups of countries. This may be stated as a general belief that the future rests in the hands of those peoples who are able to learn the secrets of nature and apply them to the betterment of standards of living in the broadest sense of material goods, leisure time, cultural improvement, etc. Technology is conceived as the key which can unlock a storehouse of plenty for the alleviation of poverty, hunger, and disease. (At the same time its military implications are by no means forgotten.) Training the manpower which can make these dreams come true is assuming an importance heretofore unprecedented in all corners of the world.

In general, the industrially advanced countries of the free world have well developed higher education systems. The scientific and engineering capabilities of such countries as the United Kingdom, France, West Germany, Canada, other NATO countries, and Japan are well recognized. However, few if any of these nations have been expanding training in science to the same extent as in the U.S.S.R., Communist China, and some of the satellite countries of the Sino-Soviet bloc. Among the major difficulties handicapping several of the free world countries are the reluctance to change the old tradition of providing a high quality training for an elite few; the financial problems attendant upon a very large expansion of the educational system to make training more generally available to the population; and—in some cases—a cultural setting which still considers education in science and engineering to be less important than education in other areas—the classics, law, and medicine, for example. These countries have generally recognized their problems, and some specific efforts to meet their needs—including expansion of educational facilities—are underway in most of them.

The less industrialized countries of the free world usually have no well developed systems for the training of scientists and engineers. Neither are there the facilities or the resources to develop them to any appreciable extent in many of the countries of Asia, Africa, and Latin-America. In many of these countries where youth of great intellectual potential are undoubtedly available for technical training, there does not even exist facilities or staff to provide adequate secondary school level instruction. In these countries the nature of the shortage of technically trained manpower frequently takes on a different character from that of the industrialized nations. Since their needs are largely developmental, serious shortages are more likely to be found in the skilled worker, technician, and engineer occupations than in the scientist categories. Progress in developing advanced levels of scientific and technical training in these countries will necessarily be slow, for it will have to be based upon strong and expanded educational systems at the elementary and secondary school levels. In the meantime, training given in the established free world universities can be helpful in training a generation of scientists drawn from the newly developing countries who can return to be the teachers of the coming generation in their own countries.

A somewhat different picture is shown in the Soviet bloc countries. Aside from the U.S.S.R., only Czechoslovakia, Poland, and East Germany were in the past relatively industrialized and therefore established producers of scientific and technical personnel. Some of the others, notably Hungary, have produced some eminent scientists. However, the Sino-Soviet bloc acts as a more homogeneous unit than the free world, on account of its unity in political action and coordinated effort to develop systematically its scientific resources. This coordination is clearly reflected in the hundreds of agreements, protocols, and conventions among these nations. It is in such agreements that much of the groundwork for developing the manpower resources of the bloc countries are laid. (Similar arrangements are sometimes made with nonbloc countries also.) Bloc countries have some problems similar to free world countries, including shortages of facilities, trained teachers, and experienced personnel. However,

their common effort appears to be making greater headway—at least numerically—than that of many nonbloc countries.

Red China in particular is developing an ambitious expansion in its engineering resources. Presently, about one-third of its graduates of higher education are in engineering; within the past few years engineering graduations have averaged 20,000 annually. Today, the total number of professional graduate engineers in Red China is about 175,000. This represents a greater effort than that of any other nation except the United States and the U.S.S.R. The real nucleus of qualified scientists in Communist China is still an older group which was trained for the most part in Western countries; however, that country is now moving to train large numbers of scientists. It appears likely that the quality of the training of these new graduates, except for some trained in the U.S.S.R., is not currently as high as that of the older scientists. However, Canadian and other free world scientists, who have been recent visitors to Communist China, have commented on the apparent success of the mainland Chinese in improving all elements of their educational effort.

Mr. THOMAS. Thank you, gentlemen.

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